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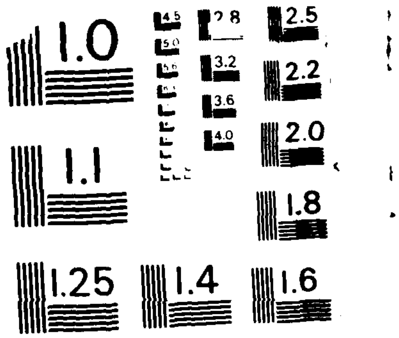

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NAVAL POSTGRADUATE SCHOOL
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FUNDAMENTAL AUTOMATED SCHEDULING SYSTEM
"FASS" A SECOND LOOK

by

John F. Cole

and

Peter MacDonald

December 1986

Thesis Advisor N.R. Lyons

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This research addresses the problems associated with integrating the Fundamental Automated Scheduling System (FASS), a PERT/CPM based overhaul scheduling device, into U.S. Naval Shipyards. Considered is the problem of how to effectivly integrate FASS into all eight shipyards. The mission, organization, duties, and constraints of the Naval shipyards are first described then the background concerning the requirements for the syst m is developed. The discussion then shifts to the implementation of the system in the shipyards and how each shipyard is utilizing its version of FASS. Finally, a summary of recommended actions and suggestions for further research is provided.

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Fundamental Automated Scheduling System "FASS" a Second Look

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This research addresses the problems associated with integrating the Fundamental Automated Scheduling System (FASS), a PERT/CPM based overhaul scheduling device, into U.S. Naval Shipyards. Considered is the problem of how to effectivly integrate FASS into all eight shipyards. The mission, organization, duties, and constraints of the Naval shipyards are first described then the background concerning the requirements for the system is developed. The discussion then shifts to the implementation of the system in the shipyards and how each shipyard is utilizing its version of FASS. Finally, a summary of recommended actions and suggestions for further research is provided.

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I. INTRODUCTION

A. PURPOSE

The current environment of the Naval shipyards is characterized by an ever decreasing workload and larger reductions in budgets. This situation calls for ever increasing and more uniform management control. The high sensitivity of management and schedule control over the overhaul duration and cost has forced the conversion from the shipyard MIS based installed PERT/CPM scheduling system to the Fundamental Automated Scheduling System (FASS) which can support real time network analysis and decision making. This real time scheduling system was aimed at allowing the shipyards to better manage manhours and material costs which are critical factors associated with cost overruns and the meeting of prescribed overhaul completion dates. With cost and time as key variables, the decision was announced on 11 July 1984 that competitive procurement was underway for Naval shipyards to procure an "off-the-shelf" system in lieu of an outside "design and build" contract. [Ref. 1] The focus of this research is to examine the Naval Shipyard scheduling system, scheduling information flow and organization; then to review the implementation strategy used at Puget Sound Naval Shipyard as compared to the strategy for implementing the new scheduling system (within the boundaries) of the management information system existing at other shipyards.

B. SCOPE

This research addresses the problems associated with integrating the Fundamental Automated Scheduling System (FASS), a PERT/CPM based overhaul scheduling device, into U.S. Naval Shipyards. Due to the uniformity of the shipyards, the recommendations and conclusions are applicable to all locations. In this light, all activities were consulted in order to benefit from the planning and experience, to date, by each activity. Implementation questions were not limited to physical or hardware requirements/uses but also covered the areas of management acceptance, utilization of existing shipyard systems, graphics utilization, dependability, and worker acceptance and understanding. The mission, organization, duties, and constraints of the Naval shipyards are first described so that the reader has a better understanding of the overall scenario.

This section is devoted to the background and profile of the Puget Sound Naval Shipyard. The general concept of Automated Scheduling is developed so that the reader will have the necessary understanding to relate the use of FASS to solve the shipyard scheduling problems. The discussion then shifts to the implementation of the system in the shipyards and how each shipyard is utilizing its version of FASS. The various versions are analyzed and alternatives are presented, resulting in a summary of recommended actions and suggestions for further research.

C. RESEARCH TECHNIQUE

Initially, a case study methodology was performed. Information from managerial, staff, and production personnel who manage or use FASS resources within the operations environment was collected during interviews. Background data on the organization of FASS resources at all activities was also gathered. On site data gathering and interviews were conducted during one ten day, two three day, and two one day visits to Puget Sound Naval Shipyard by LCDR Cole; one two day visit to Long Beach Naval Shipyard by LCDR MacDonald; one two day visit to Charleston Naval Shipyard and four day attendance of the FASS Users Group conference at Portsmouth Naval Shipyard by LCDR Cole. Background reading was conducted to better understand the shipyard scenario as well as look at commercial and industrial approaches to implementing a computerized scheduling system. The background reading consisted of shipyard organization manuals, shipyard MIS manuals, system requirements and specifications for FASS and historical information concerning the conception of the system procurement.

II. PROFILE OF A NAVAL SHIPYARD

A. GENERAL OVERVIEW

To help the reader understand the complexity of a Naval Shipyard, especially one doing both conventional and Nuclear work, this chapter is devoted to a brief look at the general duties, organization, and functions of the shipyard.

The Naval Shipyard complex consists of eight member yards located in Bremerton, WA (Puget Sound), Vallejo, CA (Mare Island), Long Beach, CA, Pearl Harbor, HI, Charleston, SC, Norfolk, VA, Philadelphia, PA, and Portsmouth, NH. The official mission assigned to the Naval Shipyard by the Secretary of the Navy is:

> To provide logistics support for assigned ships and service craft; to perform authorized work in connection with construction, conversion, overhaul, repair, alteration, dry-docking, and outfiting of ships and craft, as assigned; to perform manufacturing, research, development and test work, as assigned; to provide services and material to other activities and units, as directed by competent authority. [Ref. 2]

In order to carry out their functions, each shipyard maintains an industrial plant with extensive shop facilities: shipfitting, welding, sheetmetal, pipe, inside and outside machine, paint, service and tool, electrical and electronics, and rigging. Each shipyard also maintains a full range of personnel with engineering, design and shop skills. With the exception of nuclear work, shipyards perform basically the same functions; therefore, the Puget Sound Naval Shipyard will be used throughout this text as an example.

B. ORGANIZATION

Pictured in Figure 2.1 is the non-nuclear organization chart for the Production Department at Puget Sound. [Ref. 3] The Production Officer has direct access to the Shipyard Commander for all areas of production. The Repair Officer reports directly to the Production Officer and deals with production priorities and resource utilization. In order to discharge these duties the Repair Officer is supported by an Assistant Repair Officer, Docking Officer and a Production Control Branch Head. To keep track of the status of approximately five to ten ships on a daily basis the Repair Officer assigns Ships Superintendents to each ship.

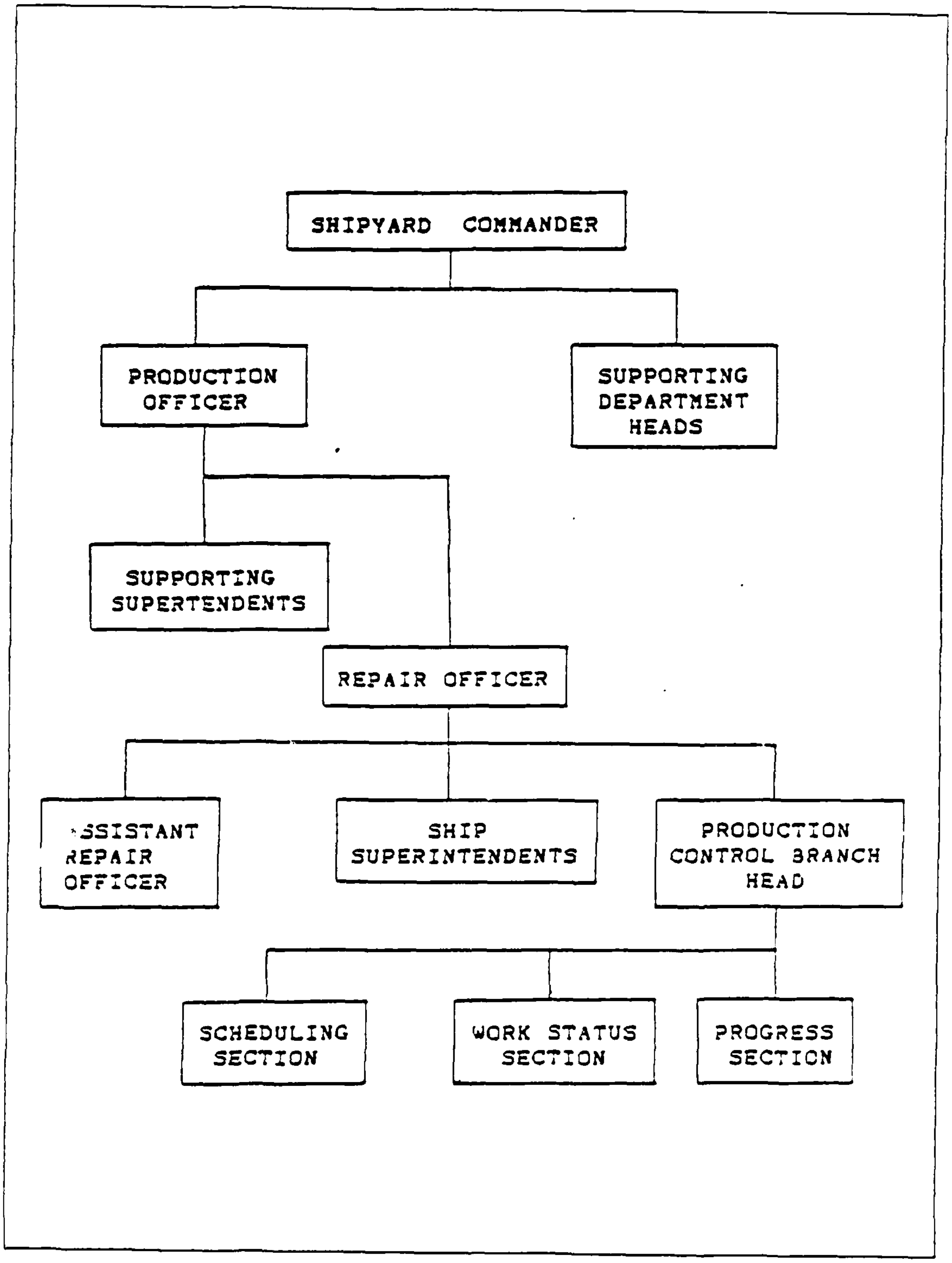

Figure 2.1 Partial Production Department Non-Nuclear Organization Chart.

The Production Control Branch will be examined in detail as this department is responsible for the control of FASS. In support of the shipyard Production Officer, the Production Control Branch is responsible for:

* "Providing workload, workforce, and scheduling data required in the management of the Production Department and for inter-department information and coordination.
* Serving as principal assistant to the Repair Officer on matters pertaining to workload workforce balance, scheduling, production material control and master work control systems for all Production Department work.
* Analyzing current, projected and long range workload and workforce, and proposing changes required to achieve balance.
* Determining physical progress of productive work (including support systems and preparatory work)." [Ref. 4]

To meet the above requirements the Production Control Branch provides; PERT CPM schedules to control and sequence the production effort, workload forecasts to manage employee resources, and project future manpower requirements. The Production Control Branch also provides progress measurement to asses actual overhaul status for comparison to the management plan.

C. OVERHAUL SEQUENCE

This section provides the reader with a background to understand a typical shipyard overhaul sequence. The easiest way to understand this process is to use the concept of event management. The event management system is based on establishing and monitoring events. An event is defined as a specific accomplishment at a specific point in time. The scheduling hierarchy contains five interrelated levels, each level more definitive and supportive of the upper tier schedules. The event hierarchy contains three levels of events with appropriate management responsibility and visibility at each level. The total event level schedule is the third level of the scheduling hierarchy. Each key event provides a discrete, well defined point in time where the status of related jobs may be examined and the progress evaluated. Shipyard Commanders or higher authority determines the key events which will determine the actual status of a ship's overhaul. A typical overhaul sequence with key events listed is provided in Figure 2.2. The same key events depicted on Figure 2.2 normally establish the critical path for the overhaul.

Although the Key Events shown make the overhaul appear straightforward with only a limited number of key events, the reader must be exposed to the complexity of

DOCK

UNDOCK

STEAMING

DOCK TRIALS

SEA TRIALS

Figure 2.2 Typical Non-Nuclear Overhaul Sequence.

completing the work leading to a key event. Figure 2.3 displays the typical interrelated systems work phases leading to a Key Event. As an example, the Engineering Plant Light Off Key Event represents approximatly five hundred job orders. The engineering plant of a destroyer class ship has four main engine spaces and up to 30 smaller auxiliary spaces. Each main engineering space has 15 major systems which contain approximately 900 valves and components. Each valve will not only require maintenance and or rework during the yard period but will also require inspection and testing prior to and during light-off. Now, add the training required by a new crew to operate a complex engineering plant with electronic systems, multiply this by four, then add the auxiliaries equivalent and the successful occurrence of a key event becomes a mind boggling evolution of enormous size that defies the best of management techniques and systems. [Ref. 5]

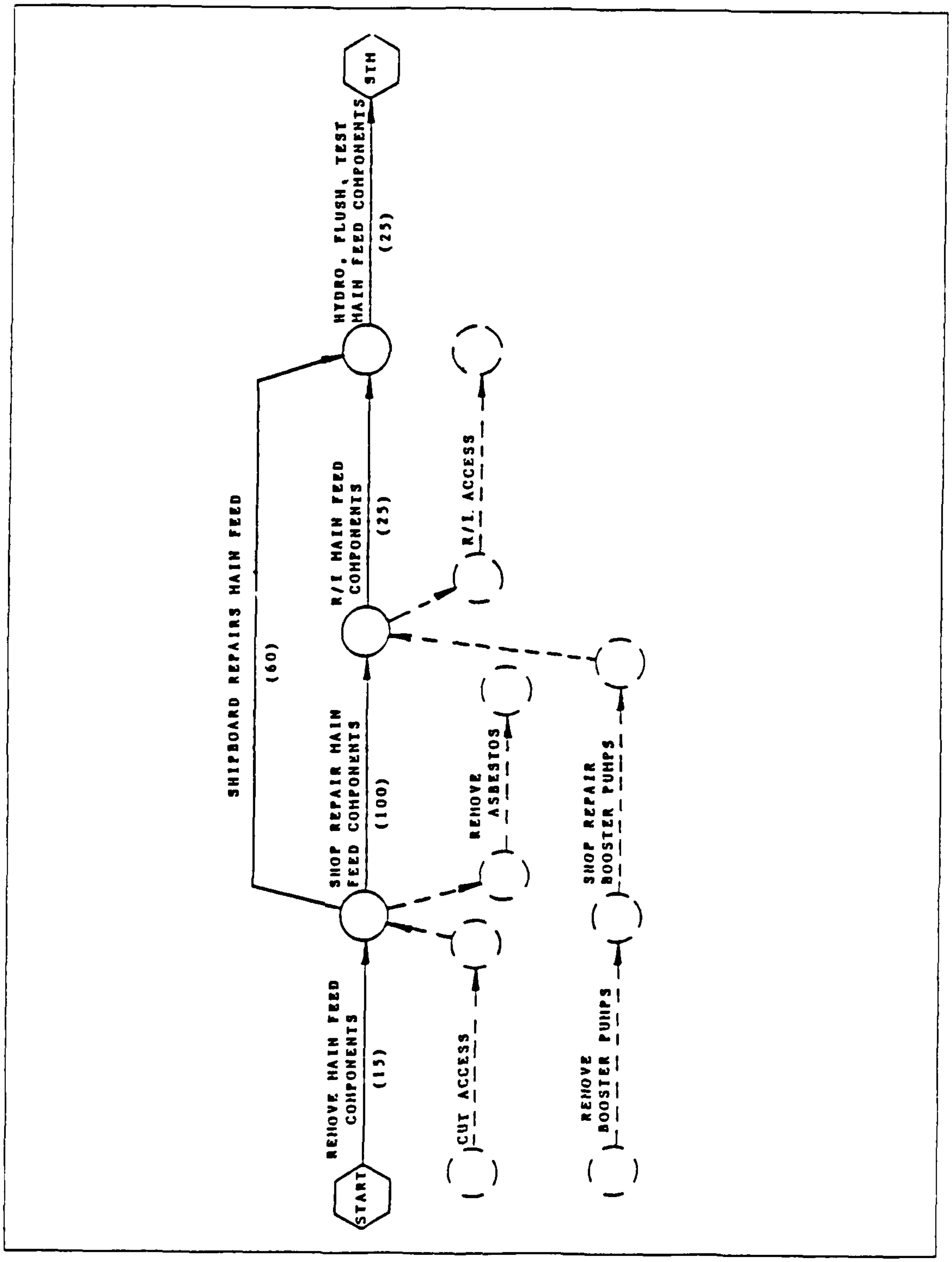

Figure 2.3 Typical Interrelated Work Phases Leading to a Key Event.

D. THE OVERHAUL ASSIGNMENT PROCESS

Normally, a Naval Shipyard does not "bid" for an overhaul contract in the same manner as a private shipyard does. Naval Sea System Commands (NAVSEA) and the Chief of Naval Operations assign workloads to individual shipyards. Such variables as construction, conversion and overhaul schedules, yard capabilities, yard specialties, existing homeport policies, and total shipwork all play a role in determining where each overhaul is assigned. The individual shipyards provide inputs but do not control the assignment process. This process constitutes a factor that can greatly affect a shipyard's planning process. Competitive policies and procedures are currently being developed which will force Naval Shipyards to "bid" against private shipyards or themselves for a portion or all of their assigned work.

E. SHIPYARD MANAGEMENT CONSTRAINTS

The constraints placed upon shipyard management are not greatly different from those placed on industry, however, they should be briefly reviewed. The four major constraints are: available manpower, authorized work, schedule adherence, and maximum allowable cost. All four constraints are interrelated. With regard to available manpower, the shipyard must employ sufficient labor skills to complete the assigned work. To accomplish this, forecasted workloads are derived and a suitable workforce is established. Unique from the public sector shipyard is the fact that all workers are government employees which removes the option of acquiring manpower on a daily basis from a union labor pool. This constraint is often costly when shipyard workload varies significantly.

Estimated cost impacts directly upon both the authorized work, (the second constraint) and maximum cost, (the fourth constraint). The estimated cost of work is produced by examining current labor and material costs. Given a maximum allowable cost of an overhaul, the ship's captain, type commander, and the shipyard develop a priority work package of required work that fits within that maximum allowable cost.

Schedule adherence (the third constraint), is mandated from the Chief of Naval Operations level (CNO). The CNO's office controls total force requirements and therefore limits the period of time that a vessel can be taken "off the line."

The four constraints have been described briefly to give the reader an overview of a few of the factors that dominate shipyard management. These elements combine to severely tax the efforts of the Production and Repair Departments to develop and maintain a ship's overhaul schedule.

F. SCHEDULE ADHERENCE

The bottom line of any repair activity is their ability to accomplish proper repairs within a limited time frame and budget. More specifically, the shipyard Repair Officer's problem is: "When several vessels are in overhaul, how can a master schedule be maintained while taking into consideration individual unit schedules, fixed overhaul workload, manpower, and cost constraints?" Other factors (i.e., political and operational pressures) often occur thereby increaseing the outside contracting requirements causing a reduction in the budget and time allotted for the overhaul. This situation requires the shipyard management to frequently answer many "What-If" questions in the planning and scheduling of their resources. The problem is very complex and no specific algorithm can be used for a solution.

III. AUTOMATED SCHEDULING BACKGROUND

A. INTRODUCTION TO AUTOMATED SCHEDULING

Automated scheduling is intended to be used to manage individual projects in conjunction with aggregate planning techniques for inter-project analysis. It is a powerful tool for scheduling project activities and for allocating scarce resources among project activities. It can also do risk analysis of project budgets and due dates. However, in the management of a project-oriented production system, such as the Naval Shipyards, major decisions must be made involving aggregate level planning issues. These decisions include the planned allocations of available resource time among projects and establishment of major milestone target dates for each project. Due to the extensive number of automated scheduling packages in use, only one such package will be covered here.

Automated scheduling requires as input data the allocations of resources to a project and its target milestone dates. Resource allocations to a project are treated as inviolable capacities for the project on the grounds that exceeding such allocations would affect other projects. The scheduling algorithms used in an automated scheduling package derive schedules meeting the target milestone dates (if feasible) without exceeding the allocated resource levels.

An automated scheduling package may be used to perform two different types of analysis which are termed "deterministic" and "probabilistic". [Ref. 6] In deterministic analysis a project schedule is derived assuming the work requirements for the activities of the project are known. In addition to the optimal schedule, resource load profiles corresponding to this schedule are provided as output. In probabilistic analysis, scheduling of the project is simulated many times with activity work requirements randomized according to probability distributions. The user must specify distributions defining probabilities of unplanned rework activities. Also, the software will incorporate uniform distributions which randomize the work content of the schedule over a set range (80-120%) of given estimates. Shipyards may evolve to probabilistic analysis when expertise is developed in the utilization of deterministic analysis.

Automated scheduling may provide confidence curves for the realization date of each milestone and confidence curves for the total hours required of each resource.

Resource load profiles reflecting a user-specified confidence level may also be obtained. Reviewing the results of such work, the user can assess the risks that trial project milestones and resource budgets cannot be met.

B. SYSTEM DESCRIPTION

Simulated scheduling is a comprehensive software package for project scheduling and analysis developed at the Operations Research Center of the University of California at Berkely. [Ref. 6] It is designed for use in project-oriented production systems which have inflexible resource capacities limiting the execution of multiple projects with uncertain work requirements. Both tabular and graphical output for project scheduled and risk analysis may be provided. This software is the result of research concerning the development of mathematical models and techniques for production management sponsored by the Office of Naval Research and the Puget Sound Naval Shipyard.

The simulation scheduling package utilizes the VM/SP operating system to compile CMS Fortran interactive commands and batch processing code. With some appropriate modifications, the Fortran code could be adapted to run on other systems.

1. Summary of Data Requirements

The data requirements for simulation scheduling are summarized below. Some of the data items are novel compared to other project scheduling software. For this reason, a brief discussion of the mathematical models of production will be provided following the summary of data requirements.

* "CPM ACTIVITY NETWORK -- An activity-on-arc network of all planned activities is specified. The "normal" duration for each activity is specified.

* RESOURCE HOURS -- For each activity, estimated total hours of each resource to be applied are specified. These resources are identified by "shop" number. Subcategories are designated by "work center" number. Activities whose resource utilization levels are not adjustable are designated with a flag in the "activity-type" field.

* TARGET PROJECT COMPLETION DATE -- The target due date for completion of all activities in the project.

* TARGET MILESTONE DATES -- Target due dates for any other events may be specified. If feasible, schedules will be developed meeting the target dates. Activities following such events will not be scheduled to start earlier than the target date, unless all predecessors are complete and it is necessary to do so in order to meet other due dates.

* SHOP CAPACITIES -- Time varying levels are specified for each resource allocated to the project. The user must specify the hours/day of each shop available to the project and an effective date such levels apply. Multiple levels and multiple effective dates are allowed.

* FLOW TRANSFERS -- Dependent activities which overlap instead of being separated by strict precedence have a flow transfer percentage specified to define the lag in the progress of the two activities.

* REWORK SUBNETWORKS -- For probabilistic analysis, subnetworks describing potential rework are defined. Each rework subnetwork consists of alternative paths of rework activities which may be required following a particular activity in the CPM network.

* CALENDAR DATA -- The starting dates of the individual projects to be scheduled simulated and a list of non-working days is provided.

* REPORTING DATES -- A list of dates for reporting shop and work center loading statistics is provided.

* MISCELLANEOUS PARAMETERS -- To initiate the program, various parameters must be specified. These include the number of simulations to be performed, the number of work days simulated, upper and lower bounds for activity intensity, and the intensity assignment policy." [Ref. 6]

2. Mathematical Models of Production

Simulation scheduling utilizes the network logic of the critical path method (CPM). In order for the scheduling model to more realistically simulate work in the project-oriented production system, such as a naval shipyard, some of the restrictive assumptions of CPM had to be relaxed. For example, the duration of many activities must be adjustable according to the amount of resources applied to the activity. In simulation scheduling, the duration for each activity is determined according to the simulated application of resources to the activity. Efficient activity durations and schedules are determined by the efficient allocation of project resources among the activities of the project.

3. Resource Utilization

In simulation scheduling it is assumed that all scarce resources utilized by an activity are applied proportionally. Using this assumption, the fraction of the total requirement for a resource that is applied to an activity on a particular day is the same for all resources utilized by the activity on that day. This fraction is called the "intensity of the activity" on that particular day.

In CPM, it is assumed that activity intensity is constant from the start to the finish of the project. The value of this constant is the reciprocal of the prespecified activity duration. However, in simulation scheduling, activity intensity is allowed to vary between upper and lower limits defined by the user. The user defines a normal duration for each activity which corresponds to a normal intensity. The user also defines upper and lower bounds on activity intensity, expressed as a percentage of the normal intensity. The user may also identify fixed intensity activities. Fixed intensity activities are ones whose intensity must be held constant at the level corresponding to normal duration. All other activities are assumed to have intensities which are adjustable between the upper and lower percentage limits.

In simulation scheduling, the user must select one of two alternative intensity assignment policies known as "upgrading only" and "upgrading and downgrading." In the "upgrading only" policy, resources cannot be withdrawn from an activity in progress. On the other hand, this is permitted under the "upgrading and downgrading" policy. In general, more efficient resource utilization and shorter project durations are feasible when activities can be downgraded as well as upgraded.

4. **Activity Dependencies**

In CPM, work flow is represented with strict precedence relationships between activities. In simulation scheduling a more general work flow relationship may be defined (known as a flow transfer) which may possibly reduce network size. An example of this relationship is: Suppose three valves are to be fabricated and then installed. As fabrication of each valve is completed the valve may be installed. CPM cannot accurately have one activity represent this situation. To be completely accurate CPM would have to use three separate valve fabrication activities and three separate valve installation activities.

Using simulation scheduling it is possible to define one activity representing the fabrication of three valves and one activity representing the installation of three valves with a 33.3% flow transfer specified between them. The 33.3% flow transfer insures that the fabrication activity is always 33.3% ahead of the installation activity. For example: Installation cannot start until fabrication is at least 33.3% done and installation cannot be 66.6% done unless fabrication is 100.0% done. In this way, the application of resources to install each valve will not be simulated until after the application of resources to fabricate the valve has been simulated even though only two activities are used. A 100.0% flow transfer value corresponds to the familiar strict precedence of activities. In simulation scheduling the default is 100% flow transfer.

5. **Probabilistic Networks**

In CPM a given network of activities is represented. In probabilistic analysis, using simulated scheduling, an overall network is represented which consists of the given network appended with randomly generated rework networks. Many different overall networks are scheduled in the course of probabilistic analysis. The user of simulation scheduling must provide input data defining the probabilities and structure of the rework subnetworks briefly described as follows.

For each rework subnetwork the user identifies the activity of the given network which immediatly precedes the potential rework. For purposes of discussion this activity will be refered to as the "test activity." The rework subnetwork following the test activity is defined in terms of alternative paths of rework activities. Each path is termed a "branch." The user defines the probability that each branch will arise following the test activity. The branch probability may sum to less than 1.0 to represent the case in which there is a chance that no rework is required.

A graph of an example rework subnetwork is presented in Figure 3.1. There are three rework branches following the test activity with probabilities 0.35, 0.20 and 0.05 respectively. For each rework activity on each branch the user specifies a normal resource mix (e.g., normal crew requirement). The user also specifies a probability distribution for the duration of the rework activity that would be realized if the normal resource mix were applied. This distribution is expressed in discrete form. For example: The duration distribution for rework activity might be one day with probability 0.25 and two days with probability 0.75. Up to five alternative durations for each rework activity may be specified.

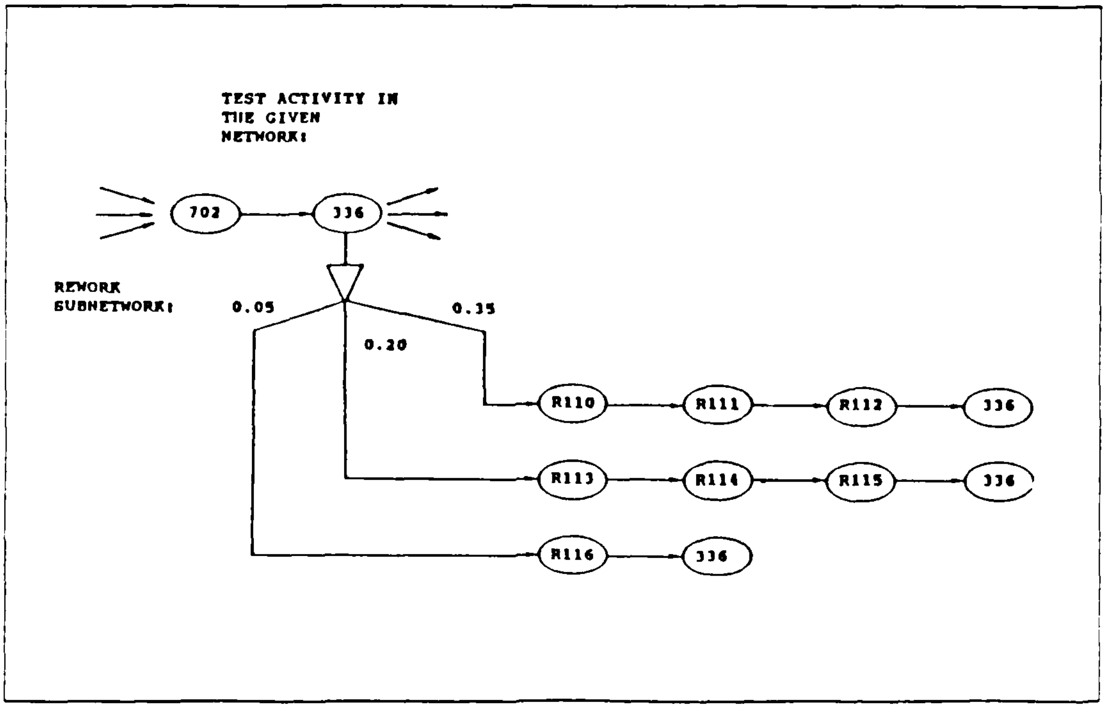

Figure 3.1 Example of Rework Subnetwork.

IV. FASS BACKGROUND

A. WHY FASS

The governing body of Naval Shipyards is the Naval Sea Systems Command (NAVSEA). In order to supervise and standardize management practices within the shipyards, NAVSEA issued NAVSEAINST 4850.9 on February 28 1984. [Ref. 7] The design of this instruction was to establish a minimum level of operational procedures in the scheduling of non-nuclear shipyard work. The instruction requires each shipyard to develop and maintain a hierarchy of five integrated schedules. The descending levels of scheduling would consist of more detail which must be upward compatible and supportive of all levels above it. The five levels of schedules must also be dynamic and updateable to reflect daily schedules up through the Key Event schedule. In addition to the scheduling requirements NAVSEA work load forecasting procedures specifies data requirements to assist in the shipyard management effort. A sample of these are:

* "Develop and maintain work performance statistics by hull type (and class if appropriate) and availability type by direct labor shop.
* Base all direct labor workload projections on data provided by the Planning Department. Where a "should cost analysis report" has been prepared, modify to "will cost" by using an approved performance factor.
* During the availability, monitor actual performance and recommend revisions to the PEC as necessary in order that the "will cost" estimate represents the shipyard's best estimate of final expended direct labor mandays.
* Prepare and maintain workload forecasts for all major direct labor shops including support shops.
* Prepare quarterly staffing recommendations for all major direct labor shops, including support shops, for use by the Management Engineering Office and other departments in establishing departmental ceiling and staffing plans.
* Produce Workload and Resource Reports and associated reports." [Ref. 8]

Although the above requirements were made to improve shipyard performance the existing Automated Data Processing technology at the various shipyards could not support the requirements. Shipyard workloads are managed by the Production Control Branch using both automated and manual techniques including hand drawn PERT CPM charts and batch inputs to the shipyard management information system. Numerous shipyards had already begun utilizing commercial software packages to assist in network scheduling; however, most were still incapable of fulfilling the NAVSEA requirements even with these packages.

The shipyard MIS in the batch mode (for example) returns schedule information in one to three days. Manual network drawing may take from two to several weeks. With these time constraints the information provided to management was too late and of very little use.

At this point in time the Production Control Branch heads of the shipyards collectively examined their inability to meet the NAVSEA requirements and jointly developed a solution to the problem. It was determined that the best alternative was to obtain a current commercial "state-of-the-art, off-the-shelf", on-line, user-friendly software package. Questionnaires were distributed to all shipyards and appropriate studies were performed to assess the actual requirements. The results of the questionnaires and the studies were transformed into a set of system specifications that described the objectives and potential benefits of FASS as follows:

1. **Objectives**

* "To shorten ship availability durations by providing the capability to quickly asses remaining work and define appropriate management action.
* To increase the productivity of the Scheduling Section by elimination of manually prepared CPM networks and bar charts.
* To have access to an automated, interactive project management system which can serve as a tool in evaluating the impact of proposed scheduling and workload forecast changes and their impact on one another.
* To have the capability to automatically "forecast resource problems" within a given schedule and identify the CPM activities involved which warrant immediate attention.
* To have the ability to input schedule adherence and progress data from remote locations.
* To establish a more meaningful relationship among project schedules, shop manpower resources, workload forecast, and progress data to aid in the analysis of performance and monitoring of schedule adherence.
* To maintain a "Historical File" for future availabilities."

2. **Potential Benefits**

* "To reduce overhaul durations and increase shipyard productivity.
* To improve the quality of shipyard schedules.
* To provide an automated interactive project management system which would serve as a tool in evaluating the impact of proposed scheduling and workload forecast changes and their impact on one another. This on-line modeling capacity would allow shipyard management to select the best option in a timely manner.
* To provide an automatic forecast of resource problems within a given schedule and identification of the activities warranting immediate attention. This would allow shop managers to review manning problems far enough in advance to properly react resolve manloading situations.
* An automated scheduling system would provide the ability to input schedule adherence and progress data from remote locations.

* To provide a more meaningful relationship among schedule, workload forecast, and progress data would allow the analysis of cost and schedule performance.

* To provide for the existence of an automated historical file which would reduce scheduling effort by allowing similar work package schedules to be re-used with appropriate changes. This would also promote the sharing of work package schedules among shipyards reinforcing overhaul standardization and applying lessons learned throughout the shipyard community." [Ref. 9]

B. SYSTEM DESCRIPTION

The ARTEMIS software procured for the shipyards was a user friendly, on-line, strictly deterministic, real time management system package. ARTEMIS has a probabilistic analysis network software package which is limited in application and therefore has not been procured by any shipyard. The ARTEMIS system utilizes a Hewlett Packard Mini 6000 series computer with various printers, plotters, and graphics terminals. General characteristics of the overall system include a common, high level command language utilized throughout the system. This allows the first time user to be led through the various cycles and allows an advanced user to bypass the initial instructions and proceed at their own pace. Self instruction facilities are maintained to help new personnel using the system. The established user may develop new data entry or retrieval formats and access data within the numerous data sets without affecting other users. The system is also capable of on line and or background processing. This capability allows the user to view the indicated process function and make corrections or changes as they are displayed.

A relational database is utilized with the ability of linking up to fifteen data sets using dynamically defined key fields. The ARTEMIS system can handle 32,000 activities per project, 64 calenders, 32 data sets and 256 resources per activity. Data input can be accomplished by using a database, manual input, or tape transfer.

The approximate times involved in obtaining an output from the system can be illustrated by viewing two cases. The initial case assumes a busy system with a detailed PERT CPM system of several thousand activities such as that required for the scheduling of a Destroyer class availability. The time required to receive an output from FASS would be approximatly one and one half hours, that is time to retrieve data from the database, analyze it, and have it ready to plot. This output allows the user to see the entire detailed PERT CPM overhaul schedule. A better example of the time savings of this system is shown by looking at a lower level of detail; that is say, the four hundred activity level of the previously discussed Destroyer class availability.

The time in this case is in the vicinity of twelve minutes: approximatly two minutes to retrieve the data from the database and approximatly ten minutes to analyze the data with the results displayed on a graphics terminal or plotted on any of the various plotters available.

The second case is an example of the day-to-day use of the system. A supervisor utilizing the system at a busy time can change information concerning five specific jobs involved in the four hundred activities. The five job changes would require about five minutes: two minutes for the data retrieval, one minute for the data entry process and approximatly two more minutes for the analysis. In this instance FASS is providing the much needed assistance to the supervisors in developing alternative solutions through schedule simulation thus illustrating the quick response time that FASS will provide to the waterfront supervisors.

The only limitation to handling multiple projects is the system storage capacity. The actual software and hardware makeup of each shipyard's system is individually flexible to meet their present needs and support that shipyard's demands.

C. INITIAL FASS UTILIZATION

While the initial requirement for FASS was to enable the shipyards to comply with the NAVSEA directives on scheduling shipyard management quickly understood the magnitude of potential applications available with the system. The ARTEMIS package provided a desktop version for project offices and foreman as well as the shipyard schedulers and could link a limited number of its terminals to the mini system. With this link capability (the combination of remote terminals and the desk top program) the problem of real time waterfront information interfacing was addressed. The system also provided the shipyard with the ability to reassign job priorities, order of start stop dates, and reconstruction of the networks to determine the affects of these changes on the critical path, resources, and other events. The "What-If" capability is an immense improvement over the existing techniques used prior to FASS. The resulting savings of the several days of manual labor required to develop a new PERT CPM schedule after any major changes were proposed during the overhaul process was a quantum and very welcome jump in processing rates.

V. FASS IMPLEMENTATION CONSIDERATIONS

A. FASS/MIS INTERFACE

Implementation of a new subsystem into an existing mainframe computer and management information system is a complex and thought provoking exercise in looking at both a near term goal (i.e., implementation of a new scheduling application) and the long term goal of complete and compatible integration. All eight Navy shipyards have acquired the FASS system for scheduling overhaul work on Naval ships. This system is a must for management in an era of reduced budgets and decreased workloads. The networking analysis and "What-If" features of FASS are critical to sound management. The network and management graphics provided by the system are necessary to maintain state of the art information presentation to shipyard managers.

A prime implementation consideration is the ability to interface between the ARTEMIS 60000 minicomputer (which runs FASS) and the shipyard mainframe (Honeywell 6060). This arrangement puts the heavy burden of "number crunching" on the mainframe which has the capacity to handle such a memory sink allowing the FASS and ARTEMIS 6000 software to assimilate and produce the charts, scheduling, and cost readout that schedulers, foreman and managers must have to judge work and time critically. The main strategies involved in implementation of the FASS System involve: (1) utilization of the mainframe data base for FASS analysis (2) providing FASS resultant schedule data to the shipyard mainframe.

Philadelphia Naval Shipyard advanced the idea of interfacing a minicomputer with the shipyard mainframe. Major areas that required thorough coordination were as follows:

* Current mainframe capabilities.
* Long term capabilities and capacities of the mainframe.
* Effect of mini micro computers on the data processing organization.
* Computer networking.

The minicomputer approach adopted by Philadelphia was designated PASS (Production Automated Support System). A line drawing of this arrangement is shown in Figure 5.1. The advantages of such an arrangement are as follows:

* Data sharing ability between the mini computer and the mainframe.

* Ability to share hardware and software throughout the data processing department and the shipyard.

* The capability of combining data files and standardizing formats.

* Fund usage optimization calling for less equipment and fewer communication lines.

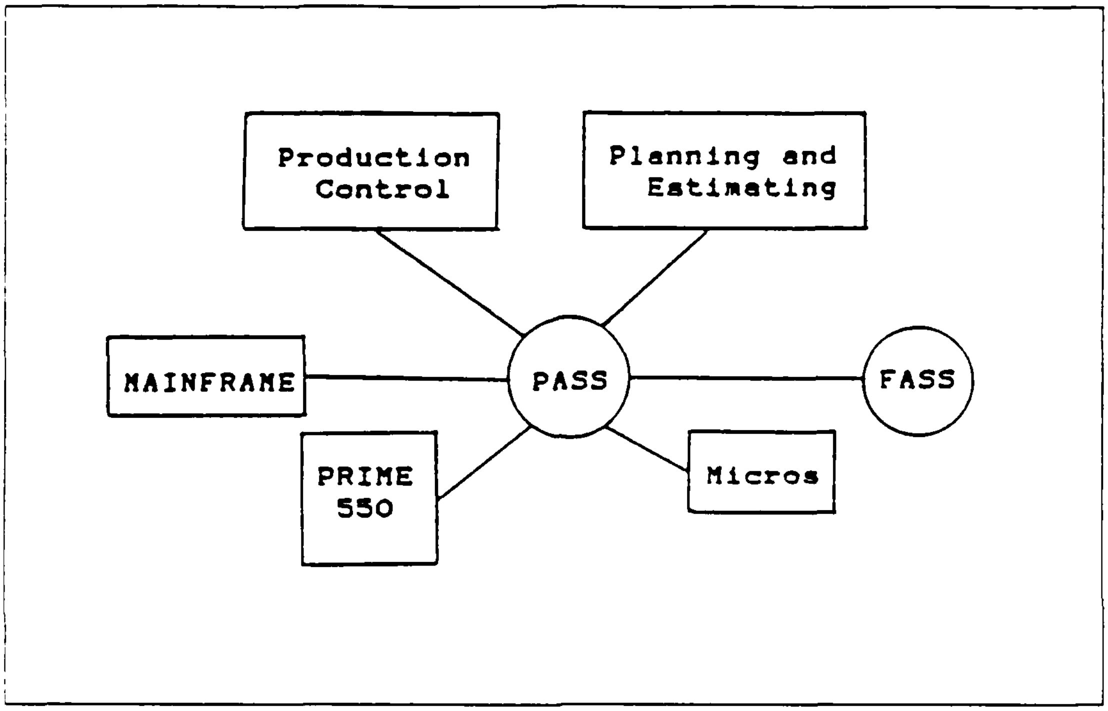

Figure 5.1 Philadelphia FASS Utilization Network.

The FASS constraints of data entry, accessibility, and memory capacity are eliminated by this PASS. Additionally, this PASS allows the existing terminals in the shipyard to obtain data from FASS. This system has been fully implemented at Philadelphia and the following benefits are already becoming realized:

* Schedule quality is improving.

* The automated interactive project management system has given the shipyard the on-line modeling capability for shipyard management to review several alternatives of schedule changes and to select the best alternative.

* Automatic forecasting of resources will allow managers to review manning problems far enough in advance to properly resolve those manloading problems.

The Long Beach Shipyard approach, as shown in Figure 5.2, is for connection of the ARTEMIS 6000 minicomputer system with the Honeywell mainframe via modem for data flow. This allows FASS to relay as well as retrieve information to the shipyard MIS in real-time fashion rather than the previous batch process that took up to three days to return the appropriate readout. The FASS software allows the mainframe to do the heavy "number crunching" and retrieves and puts that information into usable graphics for foreman, schedulers, and managers.

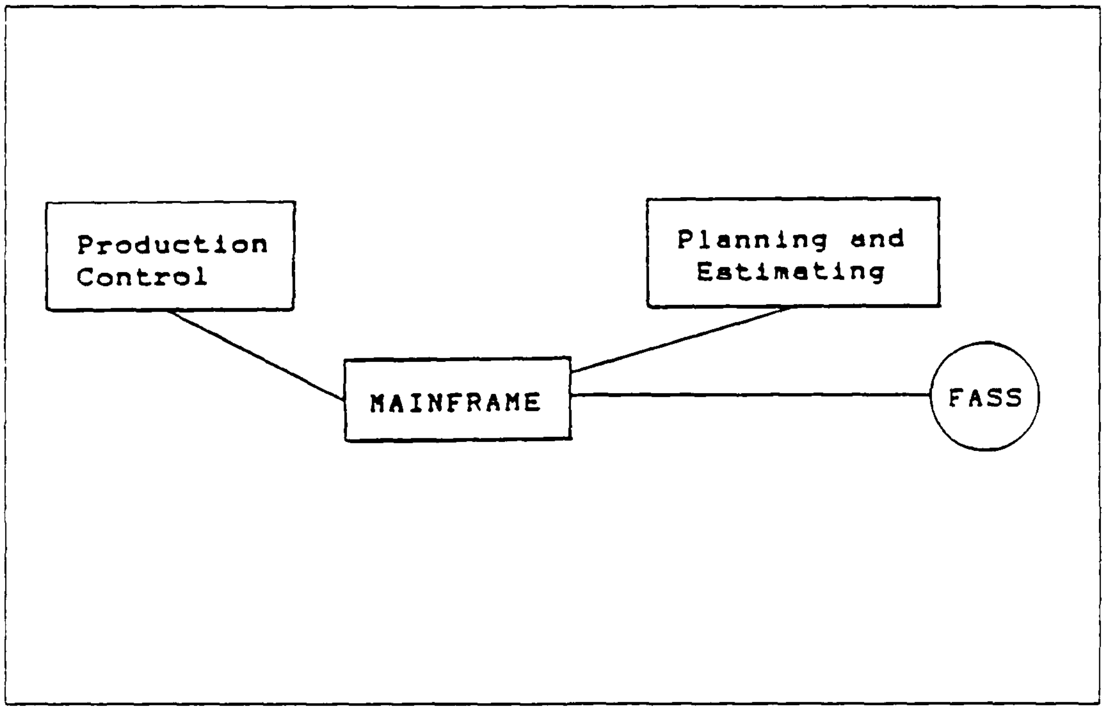

Figure 5.2 Long Beach FASS Utilization Network.

A constraint that originally developed at Long Beach has been resolved by the data processing department. In order for FASS to be completely interactive with real-time information there must be a dedicated port into the mainframe. This constraint is based on the Long Beach belief that FASS should function as a front end processor for the production scheduling (PS) application of SYMIS. Long Beach has resolved this problem by having such a port assigned to the production and planning department which has the primary equipment and usage for FASS. A typical "Plan of Actions and Milestones" for interfacing FASS to MIS is shown in Figure 5.3. In addition to the advantages cited for Philadelphia Naval Shipyard, Long Beach Shipyard is able to realize these potential benefits:

* A more direct, real-time relationship among workload forecasting, scheduling and progress data allows the analysis of cost and schedule performance.
* Reduction of overhaul durations and increased shipyard productivity.

Long Beach Shipyard is in the final stages of full implementation of its FASS system. Minor communication protocol and compatibility bugs are being corrected for the modem to be the final link between FASS and the mainframe.

Puget Sound Naval Shipyard developed a networking approach by designing a Production Control Database that would be the interface between the SYMIS and FASS, replacing the SYMIS PS application. This system network is shown in Figure 5.4. The obvious advantage to this arrangement is the fact that FASS is freed from storage and interface constraints. This type of setup allows the mainframe to continue processing shipyard weekly reporting requirements while allowing FASS to create with its graphics package more limited and specialized distribution reports. With the proper identity codes, schedulers and leadmen can update the database from any number of terminals that the shipyard has. This distributed system is a tremendous asset in keeping the real-time aspect of data viable for FASS. A new wrinkle with the mainframe database and the ARTEMIS 6000 minicomputer is that progressmen and schedulers can now conduct "What-If" studies on critical path jobs in order to see trends and to optimize job scheduling for a more efficient use of manhours. A summary of the advantages of the Puget Sound Shipyard concept follows:

* A real-time, on-line updating capability.
* Any increase in the number of shipyard terminals allow more personnel to utilize FASS update results.
* Real time work status is available for "What-If" analysis.
* The database programs are able to be utilized by other Naval shipyards due to the commonalty of mainframe systems.
* Any new mainframe purchase will not affect use of the Production Control database and FASS.

The FASS/MIS interface at the shipyards may be off-line via magnetic tape or on-line via direct communication with the mainframe. The on-line method is used daily for progress and schedule updates. The off-line magnetic tape interface is for historical or large bulk data transfer between the mainframe and FASS. An important interface is between ARTEMIS and the Production Control application. This interface

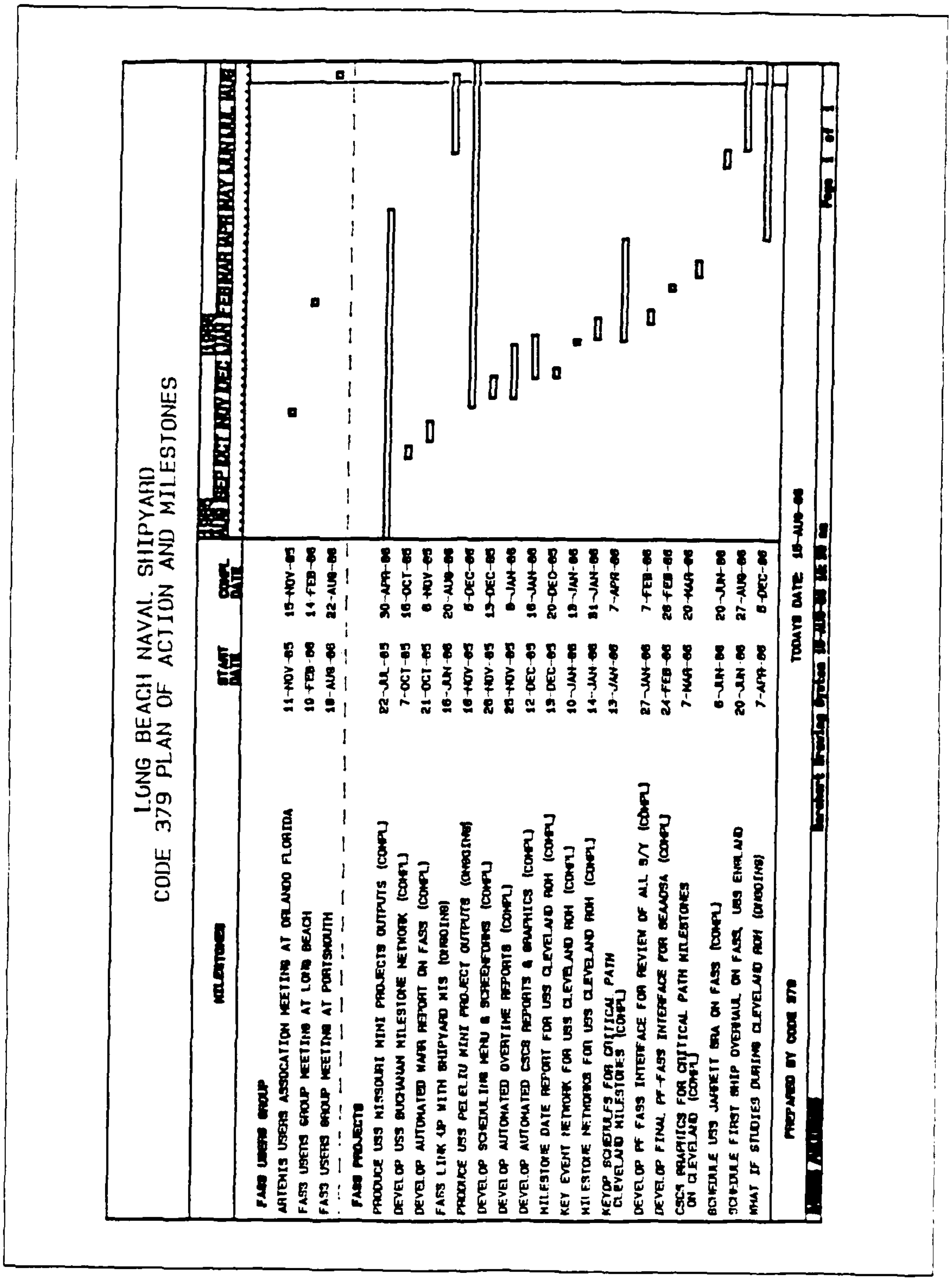

Figure 5.3 FASS MIS Interface Plan of Action and Milestones.

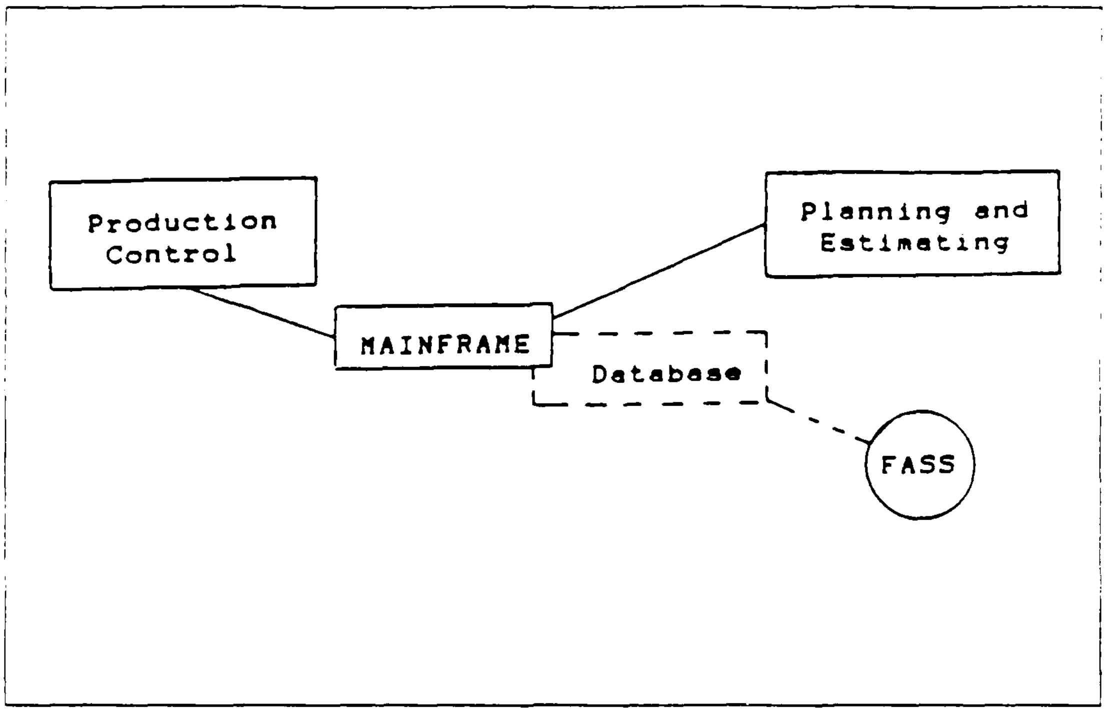

Figure 5.4 Puget Sound FASS Utilization Network.

is extremely important for the overhaul quality between SYMIS outputs and the Production Control processes. The on-line method causes the ARTEMIS terminal to act as a remote job entry station.

On the technical level implementation is all but complete at all of the Navy shipyards. The FASS User's Group (will be covered later) which is comprised of the personnel directly working with the system in the Production Control branch are constantly exchanging information that assists the others in problems that are common to all. The current ARTEMIS software release (Rel 6.6.1) is different enough from the 6.6.0 release (which is the application) that has been implemented that these data analysts share their knowledge for the good of all.

B. ORGANIZATIONAL CONSIDERATIONS

FASS is proving to be an extremely powerful tool for scheduling, graphics, job networking, and cost variance analysis. There is a need for this facet of shipyard production control to have a separate code in the nuclear and non-nuclear organization of the Navy shipyards. The approved line drawing of the current production control branch of shipyard organization is shown in Figure 5.5. A figure reflecting the projected organization required to support production control branch ADP functions is shown in Figure 5.6.

```
                  PRODUCTION CONTROL BRANCH
                         (Code 375)
                              *
                              *
     *************************************************
     *                        *                      *
     *                        *                      *
Work Status              Scheduling              Progress
  Section                  Section                Section
 (Code 376)               (Code 377)             (Code 378)
```

Figure 5.5 Typical Production Control Branch.

```
                      PRODUCTION CONTROL BRANCH
                             (Code 375)
                                  *
                                  *
   ****************************************************************
   *                   *                    *                     *
   *                   *                    *                     *
Work Status        Scheduling           Progress             Automated
  Section            Section             Section              Systems
 (Code 376)         (Code 377)          (Code 378)            Section
                                                             (Code 379)
```

Figure 5.6 Projected Production Control Branch.

The reasoning behind such a structure is that the sections of production control have the most need for the output of FASS. The above sections must be intimately familiar, on a real time basis, with the status of approximately 4000 (non-nuclear) and 1200 (nuclear) key operations on a routine ship submarine overhaul. The networks that FASS can reproduce on screen or print out at remote stations allows the aforementioned branches a graphic look at actual progress on any given job or series of jobs that lead to a key event or milestone. Prior to the acquisition of FASS this organizational structure was adequate for the needs of the schedulers and progressmen because they usually had to wait two-three days for their work inputs to be processed by the SYMIS (Shipyard Management Information System) and returned in network or graphic form for analysis. With a real time, user-interactive system integrated with the mainframe the needs of the Production Control Branch are satisfied within minutes. What has been proposed is a new section in the Production Control Branch that does not become directly involved with manpower estimates or manpower requirements (Code 376); that does not prepare, issue, and maintain shipyard schedules (Code 377); and is not responsible for determining the status of productive work in terms of physical progress (Code 378). A completely new section is needed.

A proposal has been forwarded for the formation of a Automated Systems section (Code 379) in the Production Control Branch. This new section would be responsible for the following:

* Administration of the FASS system.
* Liaison with shipyard progressmen in improvement of graphics and reports.
* Liaison with the Office of Information Resources (Code 140, Shipyard ADP).
* Liaison with all shipyard department's automated systems personnel.
* Liaison with all users of FASS or Production Control products.
* Assist the work status, scheduling and progress sections.
* Conduct all scheduling related development work.

The primary advantage of having a section specifically assigned to developmental work and improving graphics is that new ideas from other sources as well as the personnel in Code 379 can be synthesized from the ARTEMIS software. The improved graphics can be distributed to the other FASS systems in the other shipyards and all of the shipyards benefit. Currently, Naval Shipyard Long Beach is involved in this organizational change. There seems to be a question of just what FASS is and to whom it really does belong. The main emphasis in the Production Control Section is that FASS belongs to the Scheduling Section (Code 377). This does not take into account the other facets of FASS such as the cost schedule variances that FASS can graphically portray or the different forms that tie scheduling to manpower, milestones, and money. The somewhat narrow strategy is that FASS should belong strictly to the

Scheduling Section. A more enlightened view is the formation of the separate section to assimilate information from the other shipyards and for one small group of people to have the expertise of the system. In all of the shipyards 1-9 people work with FASS. The move is to hire more clerical types for the pure administrative burden that accrues with such a complex system. At Long Beach there are three people: a supervisor, a technical operator, and a general computer specialist. This is not really enough to completely keep up the daily processing of information from the mainframe on the three or more ships that are nearly always in overhaul. It seems logical to have a separate section for FASS expertise and to allow the other sections to carry out their primary responsibilities in the most efficient manner possible. Portsmouth Naval Shipyard, Long Beach Naval Shipyard and Puget Sound Naval Shipyard have implemented the formation of the Code 379 while there is a nearly equal division among the other shipyards in shifting to the Code 379 organization or maintaining the control of FASS in the Code 375 office. Increased organizational effectiveness is more easily attained by specialization of functions. It is logical for Code 379 to act as the primary FASS experts and let Code 375 attend to the larger functions of production control.

C. FASS USERS GROUP

With eight shipyards, as with any eight organizational entities with the same systems and goals, there is the tendency to carry out business eight different ways. The eight Navy shipyards operate under more stringent guidelines than any private sector shipyard. Because the jobs in the shipyard are civil service there are problems in reducing the work force when an overhaul is completed. This somewhat constant work force becomes extremely expensive and cost inefficient in leaner times. The same guidelines apply to the ADP section of the shipyard organization. The drive for production efficiency is an overriding consideration in the public sector shipyards. To ensure a semblance of commonalty and to keep effectiveness at as high a level as possible, the FASS User's Group has been organized comprised of the FASS user's and implementers in all eight shipyards and SEAADSA. This user group is designed to improve inter-shipyard communications in the FASS area by the sharing of ideas and products, by setting priorities for system enhancements, and to expedite the development of FASS to current state-of-the-art technology. The avowed purpose of this group is to improve shipyard operations, reduce overhaul and maintenance costs, and finally to reduce the durations of regular overhauls. The user's group accomplishes this lofty aspiration by the following means:

* Establish and maintain a minimum level of commonalty in the areas of computer hardware, software, and scheduling terminology.
* Establish and maintain communication between users and automated scheduling systems.
* Share and exchange ideas and products among shipyards.
* Promote trust and confidence among the shipyard users.
* Surface scheduling system problems and provide mutually supportive resolutions. [Ref. 10]

This FASS User's group was initiated to develop a strategy to assist each shipyard in obtaining productive status with the FASS system in the shortest possible time. Two of the main ideas of the group were the establishment of a core database and the problems concomitant with interfaces.

The core database was to serve as the point of departure for standard process and reports development. An input by the user's group was the use of consistent conversions of database elements so that any communication between the individual shipyards would not be stymied by different and essentially undecipherable computer code. It was established that the contents of the core database be limited to those data elements used by the majority of the shipyards with built-in capabilities for database expansion when FASS capabilities were more fully realized.

The interface problem was recognized early as one of the most important capabilities to be developed between FASS and the shipyard mainframe. The group decided that the interface be accomplished by either magnetic tape or a communications link (2780 3780 protocol). For example; Long Beach Naval Shipyard uses the communications protocol as the interface link with the mainframe while the magnetic tape is a historical record. Long Beach also has the communications link via modem to the other shipyard FASS systems for data exchange. At the present time this FASS User's Group meets twice a year to discuss problems relating to all of the shipyards. The accomplishments of the first three FASS User's Group conclaves have been synopsised below:

* A common core database has been developed for FASS and implemented by all shipyards and SEAADSA.
* Electronic communication procedures and transfer of software routines between shipyards have been developed and implemented.

* An electronic mail weekly news bulletin was implemented and shipyard procedures for use of the bulletin were established.

* Procedures for eliminating redundancy of programming by shipyards and SEAADSA have been established.

* Procedures for sharing and soliciting better business practices have been established and utilized.

* Sharing and exchange of methodologies and products between the shipyards has been enhanced by the User's Group.

The latest meeting held in September 1986 dealt with the growth potential of the Code 375 branch of the shipyard. The consensus is that Code 375 rather than the shipyard ADP must define and design production information systems. This is a radical move for decentralization in the shipyard data processing organization. At this stage of implementation the User's Group is fine tuning the FASS system and developing new ways for the ARTEMIS software to produce exactly what they want in the way of graphics and reports. The FASS User's Group is concerned with two main difficulties that may impede full and accurate implementation: (1) Cost Schedule Control System (which will be discussed in the following section) and (2) the Navy's competitive bidding policy toward overhaul of ships and submarines. There is tremendous concern among all the FASS users that conflicts of interest may arise in the shipyards between getting the bid for a ship overhaul and exchanging information that may make one shipyard more efficient than another. As can be recalled, one of the cornerstones of the FASS User's Group charter was the sharing and exchanging of ideas to make all the shipyards more efficient and to cause shorter overhauls which would save taxpayer money. This conflict could possibly break down productive communications between the shipyards and cause damage to them all. A strong solution that has been proposed by the User's Group is for all the Navy shipyards to bid as a corporation rather than as individual entities. This would at one stroke remove any secrecy and would keep the ideas and exchanges of data flowing between the shipyards.

The FASS User's Group is the strongest force in implementing FASS at an equal pace in the shipyards. The exchange of data is helping each shipyard to be more efficient and cost productive. The value of the User's Group is the main reason FASS is becoming as powerful a tool as it has become.

D. COST/SCHEDULE CONTROL SYSTEM

The Cost Schedule Control System (CSCS) is an idea that private industry has used for years. The primary reason that Naval shipyards have adopted this system is to maintain shipyards in a required state for wartime readiness and still meet technical requirements of ship overhauls ahead of established schedules and at a reasonable cost, preferably under cost. These lofty ambitions are striven for without sacrificing gains made in quality and scheduling. The system is designed for the middle managers of the shipyard, the general foreman, and shop foreman. A typical shipyard system hierarchy is shown in Figure 5.7. [Ref. 11] The elements of a CSCS system include:

* Discipline-bias toward improvement.
* Control of overhead expenses.
* Work organized into manageable packages.
* A plan to accomplish each package.
* A measurement of costs of work performed.
* A measurement of the physical progress of work.
* Ability to detect variances from the plan and ability to take corrective action. [Ref. 11]

This system is designed to reduce costs in the Navy shipyards by adhering to the principles stated below and shown in Figure 5.8:

* System based on integrity. Actual cost data and actual schedule progress data will be collected for producing a precise report of actual performance.
* The highest level of the cost hierarchy will be the project budget.
* Project work scope will be broken down into relatively small work task elements which will be assigned a cost estimate and a performance schedule which will be the structural foundation for measuring cost and schedule performance.
* Cost performance will be measured by comparing actual costs for work performed to planned costs.
* Schedule performance will be measured by comparing actual progress to planned progress at the appropriate levels.
* Deviation of actual performance from planned performance will be resolved by the responsible line manager. [Ref. 12]

The primary reason that CSCS is mentioned in the implementation of FASS is that even though the full power of FASS is not yet fully understood by the FASS users, this new concept is being added to already burdened staffs. Three of the shipyards, Long Beach, Mare Island, and Charleston, have arrived at three methodologies for CSCS FASS implementation. Long Beach plans to use the shipyard

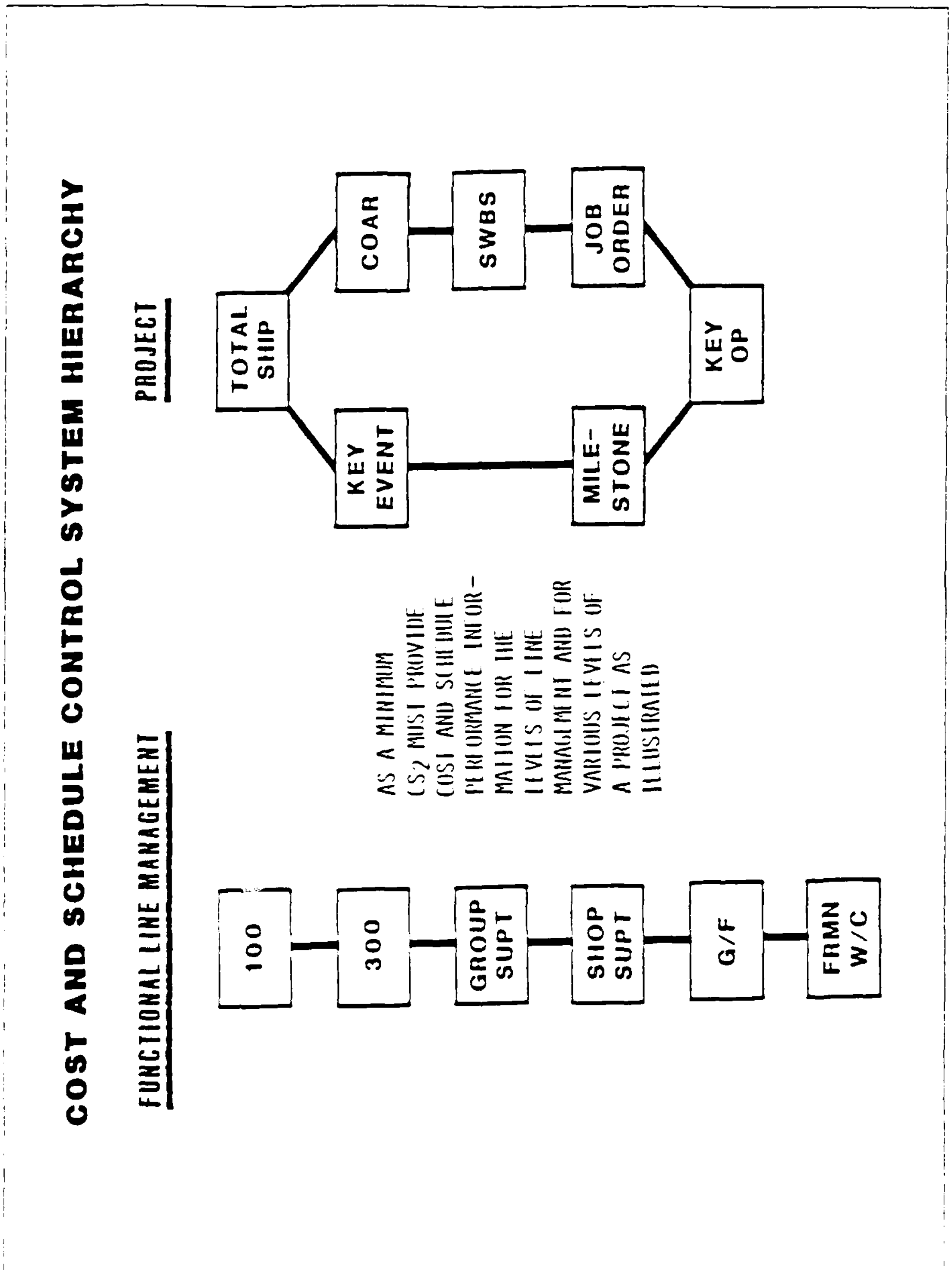

Figure 5.7 Cost Schedule Control System Hierarchy.

mainframe for CSCS "number crunching" and down-loading to the ARTEMIS software for graphic representation as shown in Figure 5.9. Mare Island plans to interface the shipyard mainframe to FASS to down-link data from the SYMIS and use ARTEMIS software to analyze, and to produce reports and graphics for CSCS. Charleston is using the Mare Island approach with the exception of using a different software package with ARTEMIS. The User's Group meeting in September held a separate conclave dealing specifically with CSCS. The consensus was that Long Beach and Charleston provide a summary of their systems development to date and to identify the differences between the systems. The group also felt that CSCS calculations would be best achieved on the shipyard mainframe and that the standard graphics should also be generated on the mainframe due to the volume and distribution considerations of the reports. The main complaint of the User's Group concerning CSCS is the fact that FASS is being utilized for implementing CSCS in the shipyards. This is not what FASS was designed to do. FASS is first and foremost a scheduling tool and the addition of a non-scheduling memory sinking concept like CSCS is counter productive to a full understanding and utilization of FASS.

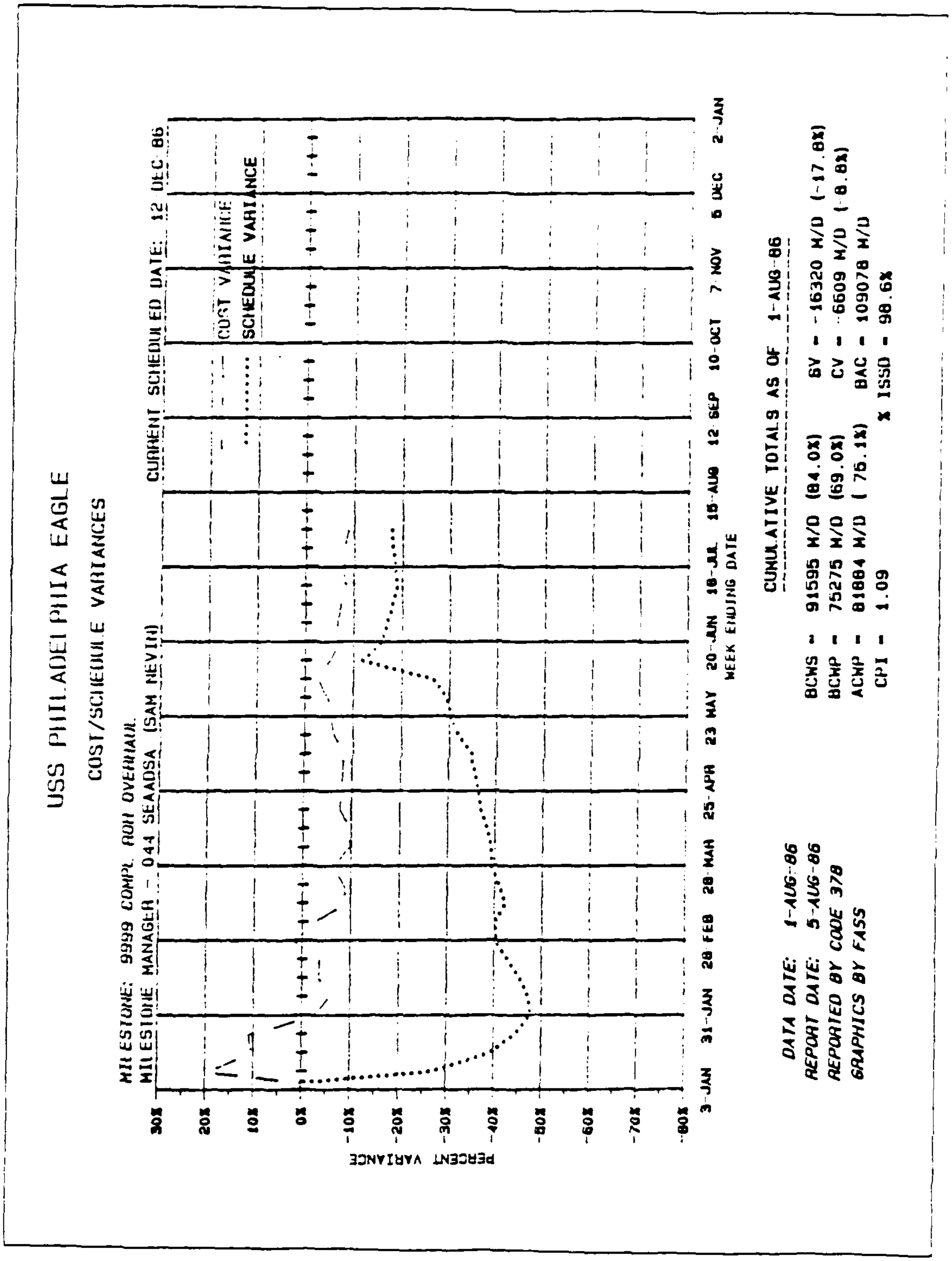

Figure 5.8 Typical Cost/Schedule Variances Graphics.

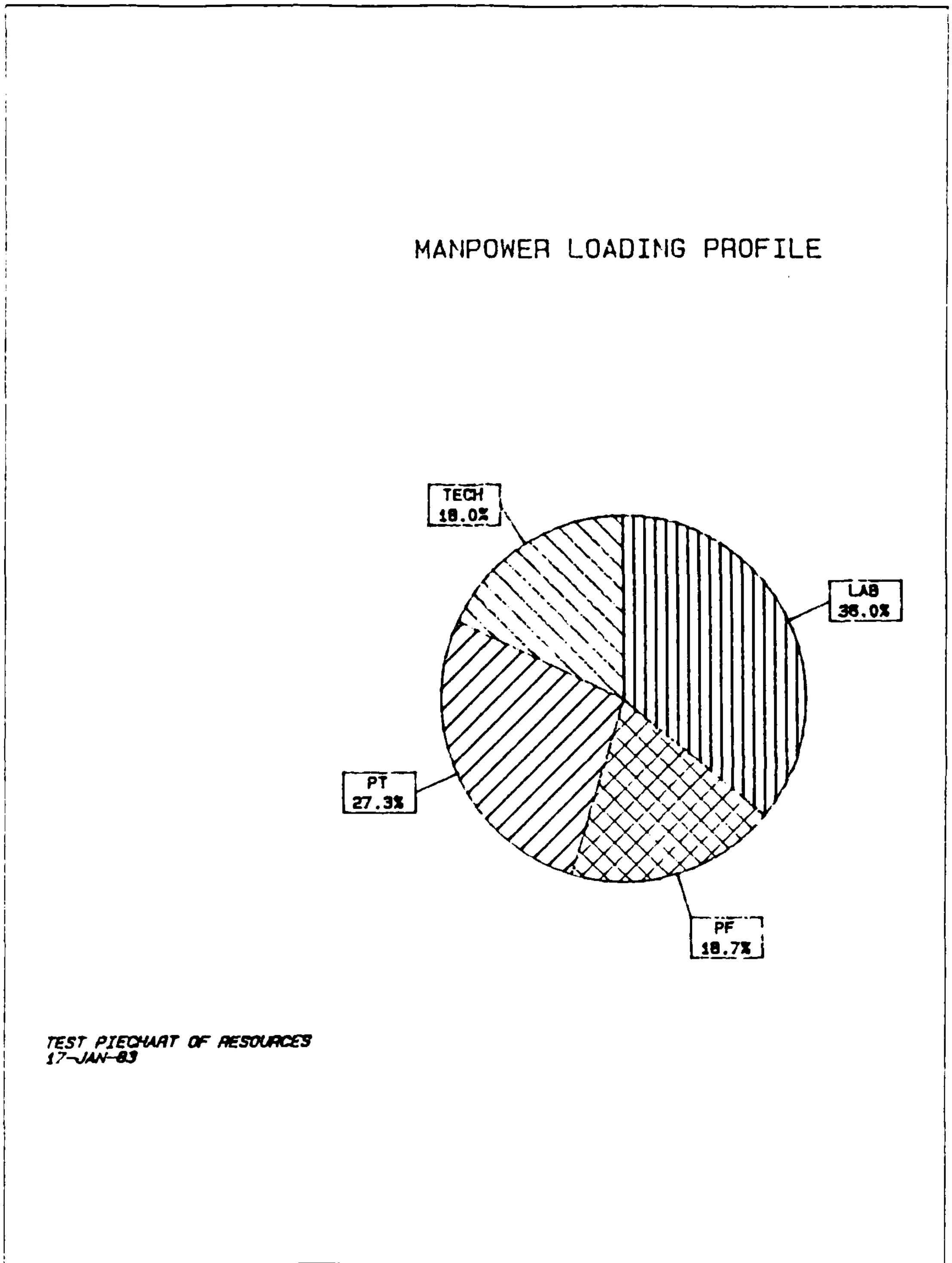

Figure 5.9 Typical ARTEMIS Software Management Graphics.

VI. CURRENT FASS UTILIZATION

A. PUGET SOUND

Puget Sound Naval Shipyard has fully implemented FASS and is coping with the Cost Scheduling Control System. FASS at Puget Sound is menu oriented and password controlled. There is a nuclear and non-nuclear master schedule built into the memory that can be altered with any special overhaul key events, milestones, or jobs that may be particular to a certain type of ship or submarine. The system's network for the Production Planning Branch is depicted in Figure 6.1. Puget Sound has the largest inventory of remote printers and plotters of all the shipyards. Long Beach Naval Shipyard is in the process of shifting some of that procured excess to their FASS site thereby recognizing an early cost benefit from the Navy's overall FASS system. Puget Sound has progressed to the point that the weekly reports endemic to Production Control have been placed on permanent disk in the FASS computer room and are no longer a part of the shipyard MIS produced reports. Puget Sound is also utilizing the "What-If" capability of FASS allowing them to take advantage of the ability of the schedulers, foreman, or management to change the event or the duration of the milestone or the calender resulting in a new event report incorporating these changes and any other concomitant changes in the schedule.

Puget Sound has incorporated the Cost/Scheduling Control System (CSCS) concept into their system and the shipyard MIS. They have recognized the value of CSCS to the shipyard and have produced their own training manual. This manual shows the schedule hierarchy and explains the CSCS graphics terms. [Ref. 11] As stated in chapter five the shipyard mainframe must still do the massive numerical manipulations to produce the schedule and cost variances while the FASS graphics produces the final printouts. Puget Sound has found that the key to success with CSCS is a combination of the following:

* Manageable "packages" of work.
* A plan to accomplish each package of work.
* A stable estimating base.
* Manhour "budget" for each package.
* Accountability.
* Accurate labor charging.

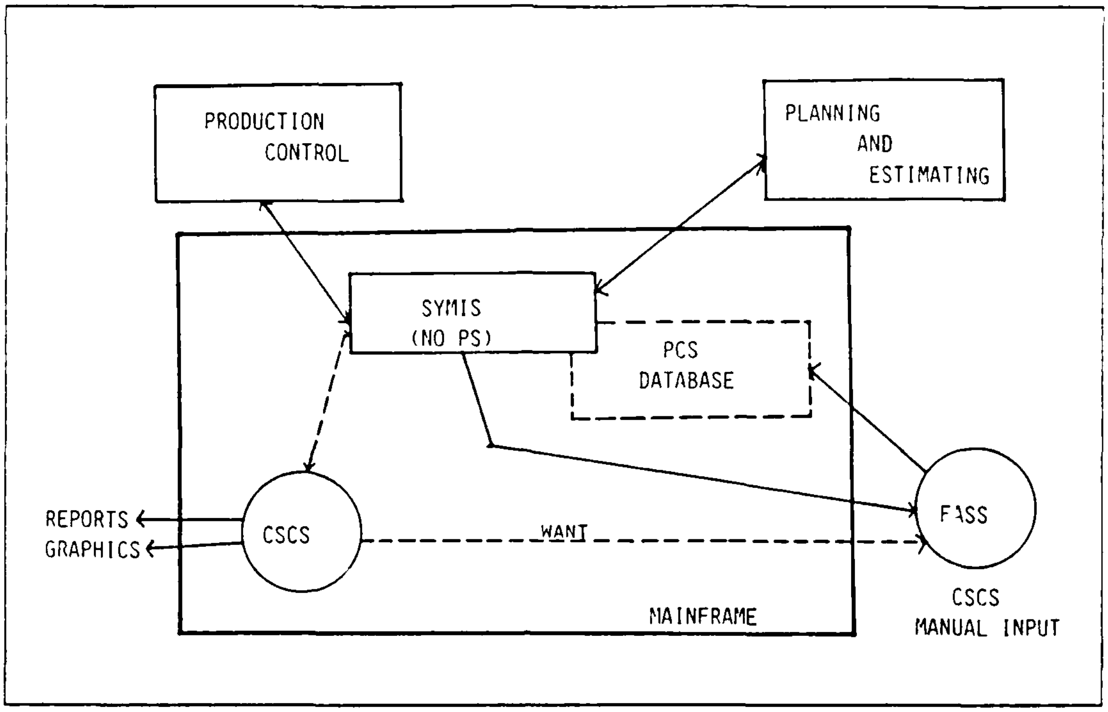

Figure 6.1 Puget Sound Production Planning Branch Network.

* Surveillance of labor charges, physical progress/completion, and specification adherence.
* Real-time reaction to variances.
* Investigation/resolution.
* Discipline!

Puget Sound has organizationally found that Code 379 has control of the FASS system in all respects. The reasoning behind this is that the system is in the hands of the people that must be familiar with it to best accomplish their jobs.

B. LONG BEACH

Long Beach Naval Shipyard has implemented their FASS system as depicted in Figure 6.2. This has allowed the mainframe MIS to contain the massive memory and allows FASS to remain relatively unencumbered to produce their scheduling reports. Long Beach has also developed their own set of CSCS graphics in conjunction with the MIS. Additionally, Long Beach produces the automated workload and resource report (WARR) that is turned in monthly to NAVSEA. Long Beach has also produced an automated overtime tracking report that allows for an audit trail when required. Long

Beach has also developed an automatic update of any overhaul schedule based on the real time progress as extracted from PCC-268 data.

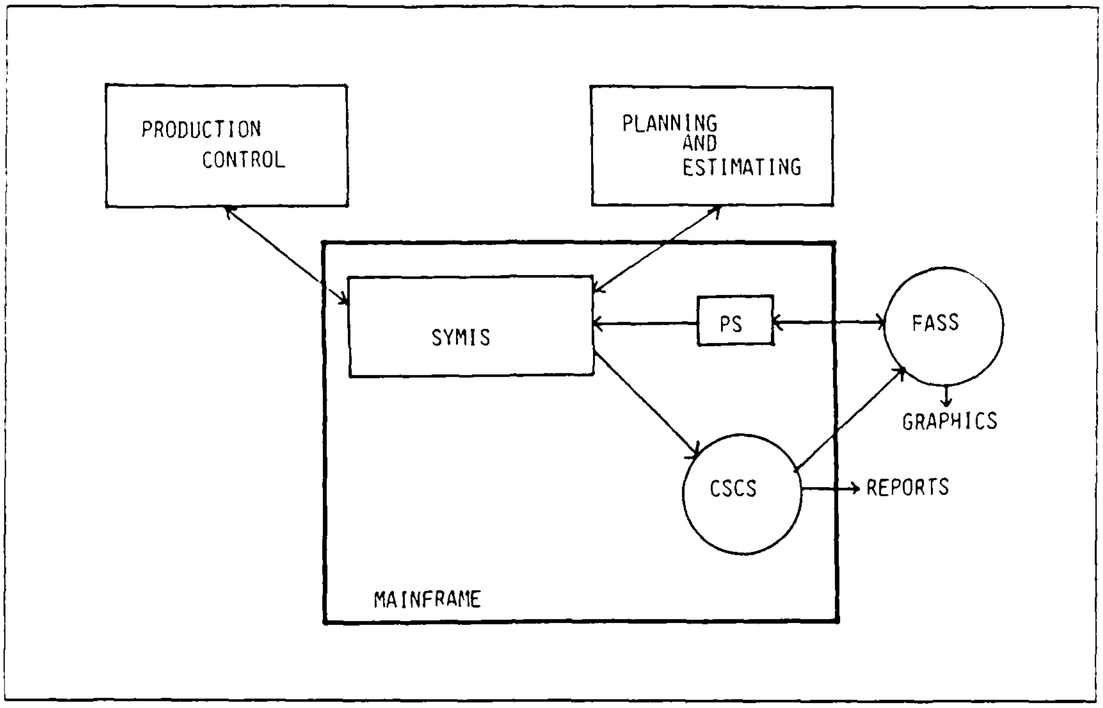

Figure 6.2 Long Beach Production Planning Branch Network.

Long Beach has developed FASS to its fullest potential by pushing the system as far as it will go then modifying it to go further. They have developed resource scheduling techniques that allow maximum utilization of the workforce and already reduced the overhaul time required on one ship by believing in the output of FASS. Long Beach has gone to the other shipyards and is in the process of building a master library of ship overhaul schedules based on standard work breakdown structures which results in the avoidance of redundant work by their own schedulers. This aspect shows great promise of significantly reducing overhead in future overhauls. The immediate advantage of having such a library is the time reduction that occurs in responding to contract awards in the competition with other public and private shipyards.

Long Beach is experiencing a slow down of the system while doing large networks. It is taking as much as 24 hours to analyze and report on some large networks. The apparent source of this slow down is the float allocation procedure is proving to be very time consuming. What this points out is the fact that the minicomputer which is the heart of FASS may still be too small in memory capacity to handle very large projects. Long Beach feels that although FASS is a scheduling tool that has unlimited potential in theory it is quite limited in real life by its memory capacity. Due to these limitations most of the work has been in producing reports for schedulers and shop foreman. The automated overtime and CSCS functions have been regulated to third and fourth priorities.

Other than nagging mini mainframe interfacing problems the only major casualty to their system has been an unreliable CALCOMP 1077 plotter which is now repaired. The information gleaned from the repair of this plotter in relation to optimum vacuum settings and the squaring of the reference points is of great interest to the other shipyards that are experiencing the same problems with their own 1077's.

Long Beach has implemented CSCS on the FASS system using the guidance provided by NAVSEA. [Ref. 12] Additionally, Long Beach has completed CSCS reports by performing keyop audit checks on time cards.

Organizationally Long Beach subscribes to the Code 379 approach as reflected in Chapter V. This approach allows the three people who are intimately familiar with FASS to look at ways of improving the scheduling aspects and the report formats to the schedulers who use them. This removes the burden of R&D from the Code 378 schedulers and allows Code 379 to constantly improve FASS operations and outputs.

C. MARE ISLAND

Mare Island, along with Portsmouth Naval Shipyard were the first shipyards that received the FASS system. The software they started with was ARTEMIS 5000. ARTEMIS 6000 is now in place at all eight shipyards. This has necessitated some small change-overs in procedure for Mare Island. They have a nuclear and non-nuclear scheduling master residing on their FASS mini. Mare Island also uses basically the same networking model as Puget Sound shown in Figure 6.3. There have been small problems in interfacing with the mainframe but with the help of the FASS User's Group they have been solved satisfactorily. Mare Island, organizationally, has FASS in the Code 377 section of Production Control. In all other respects Mare Island most closely resembles Puget Sound in its current FASS utilizations.

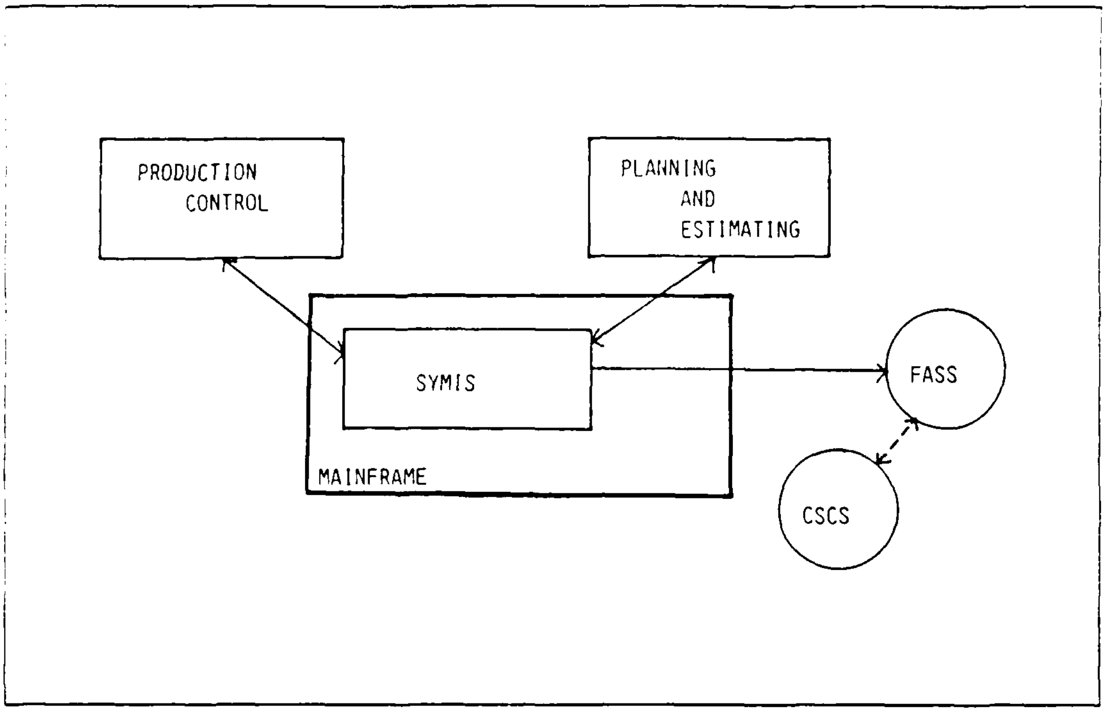

Figure 6.3 Mare Island Production Planning Branch Network.

D. PEARL HARBOR

Pearl Harbor has fully implemented FASS into its Production Control branch. Additionally, Pearl has implemented an excellent CSCS package into their system. Their CSCS system has been tried on a ship and two submarines. Both the nuclear and non-nuclear schedules have been exercised. Pearl Harbor also uses basically the same network model as Long Beach Figure 6.4. The shipyard has divided the responsibility between Code 377 and Code 379. Code 377 schedules the work and Code 379 is packaging the work to support the individual tests. For example, work required to support test number 1 will be packaged and scheduled separately from that work which would support test number 2. The end product of such a sequence of work packages is the test of the entire package as a key event or milestone. An innovation that Pearl has developed in Code 143 is a program that extracts data from the SYMIS onto a PC. This is done once a week and is reviewed by the individual keyop mangers. This data is then run through FASS for local reports only and overall efficiency is increasing. This innovation is in its infancy but is already showing great promise.

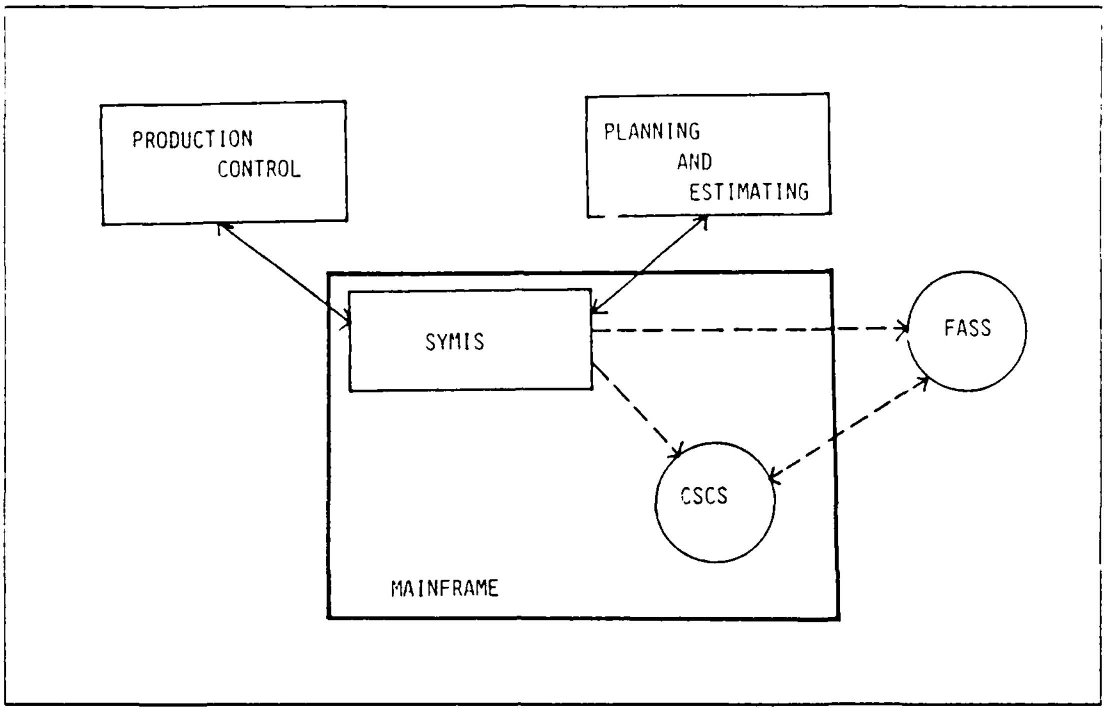

Figure 6.4 Pearl Harbor Production Planning Branch Network.

Pearl Harbor shares the same misgivings as the other shipyards regarding CSCS. Pearl Harbor has issued a fairly extensive instruction detailing the system in effect. Included in this instruction are formats for three reports that could be valuable for other shipyards. The reports are synopsised below:

* PSL-05A = MILESTONE-KEY EVENT SCHEDULING INTERFACE

    1. Combines nuclear and non-nuclear work into one report grouping keyops to the milestone-key event interface showing most recent status information.
    2. Program highlights keyops that may be deficient.
    3. Program performs automated rescheduling of keyop when the master milestone is revised.

* PSL-O5B = CURRENT MKE AND PRODUCTION CONTROL SUMMARY

    1. Summarizes potential problem keyops and shows any increases or decreases from previous reports. These reports are issued once a week and are a tremendous asset for the keyop managers in finding early problems

Pearl Harbor has developed its own backup procedure to reduce the possibility of lost work. A auto backup will occur whenever a user logs off his ID, thus users do not have to remember to backup their work every day. The only drawback to this procedure is that it now takes from 20 seconds to three minutes to complete log off. This lost time though not important now, will be when the system is more fully loaded.

E. PHILADELPHIA

Philadelphia Naval Shipyard is the shipyard that uses the minicomputer (PASS) as an interface between existing shipyard computers. The line diagram is shown in Figure 6.5. In fact, FASS is a front end user of PASS to the mainframe. CSCS has not been implemented at Philadelphia at the present time. There are over 200 individual jobs required in making it fully operational. Code 226.1 and Code 226.2 personnel have the new system 90 percent implemented. Long Beach's PC 268 program has greatly aided Philadelphia in coming as far as it has in implementation of CSCS. In other respects, Philadelphia is no different from the other naval shipyards. Files are down-loaded from the Honeywell mainframe to FASS for graphic outputs. Code 226.2 is moving toward developing automatic updates based on costs. Philadelphia has a large SLEP (Service Life Extension Program) in effect and it produces specialized reports for those overhauls that are different from the regular overhaul reports that FASS has produced. Philadelphia, Long Beach, and Mare Island have the float allocation program installed in their FASS system where the other shipyards do not. Philadelphia feels that the float algorithm is not strong enough to support overhauls. It sometimes takes as long as two weeks to get results from their resource loading programs. Another problem has been the inclusion of the SLEP program into FASS. It seems that FASS is too small storage-wise to support it. SLEP takes up to 55 percent of all FASS memory and leaves only enough room to carry one FF size ship in the remainder of its memory. This necessitates a greater than normal use of the shipyard mainframe for the scheduling aspects of the other ships in overhaul. Philadelphia has a good working FASS system and the PASS minicomputer has proven to remove some of the memory and time-lag problems that affect the other shipyards.

F. CHARLESTON

Charleston relies heavily on the mainframe. The line diagram is shown in Figure 6.6. Graphics are done on the shipyard MIS while all reports are generated by the MIS and down-loaded to FASS for presentation. Charleston seems to have some capacity storage problems that the other shipyards have not reported. They also need a second 1077 plotter to accomplish the graphics that are required. CSCS has proven to be impractical for FASS at Charleston and they have not placed as high a priority

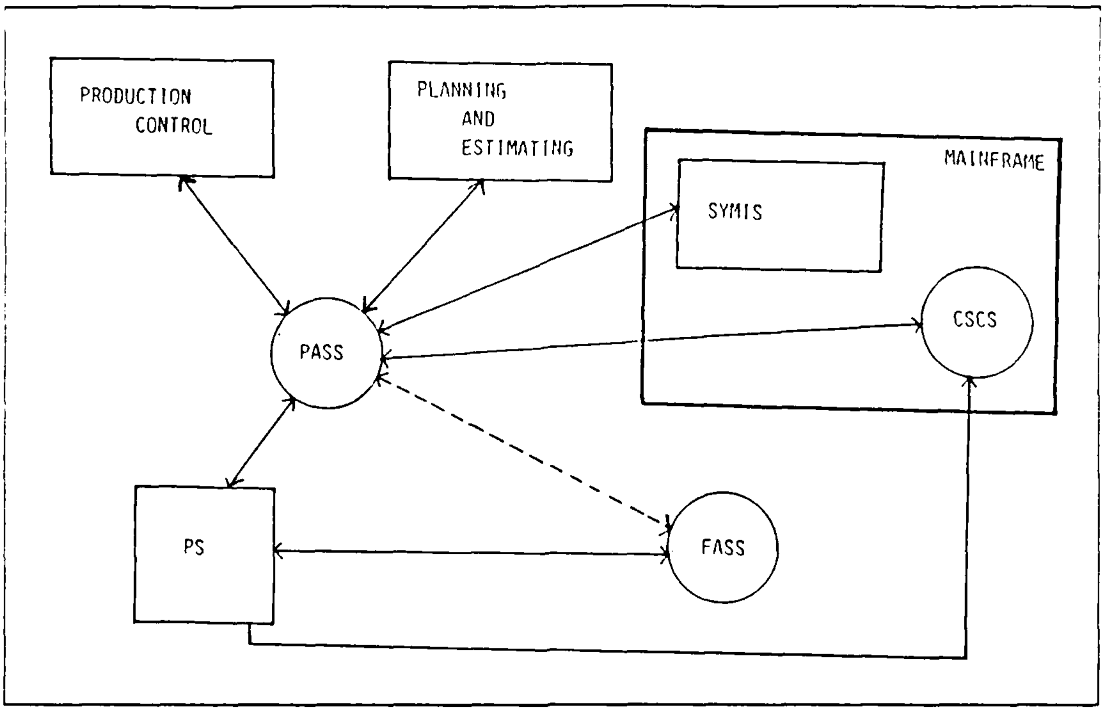

Figure 6.5 Philadelphia Production Planning Branch Network.

as some other shipyards have. Organization-wise Charleston utilizes the normal shipyard structure where Code 375 is in charge of FASS. Charleston seems to be progressing well with their utilization of FASS in the way it was designed: For scheduling. With the exception of the storage problems cited above, Charleston does not seem to have any major problems with FASS.

G. PORTSMOUTH

Portsmouth Naval Shipyard, along with Mare Island, was the first to acquire and implement FASS. The network line diagram is shown in Figure 6.7. With the older ARTEMIS 5000 software they have had cross-over problems in using the ARTEMIS 6000 but these appear to have been overcome. As with the majority of naval shipyards Portsmouth has a nuclear and non-nuclear master schedule residing in FASS. Graphics are done on FASS as well as the reports that are peculiar to production control. Their FASS routines are not menu driven. They also have a paucity of storage even though they have a library disk such as the one Long Beach produced. Portsmouth espouses wholeheartedly the CSCS concept and conducts classes on the

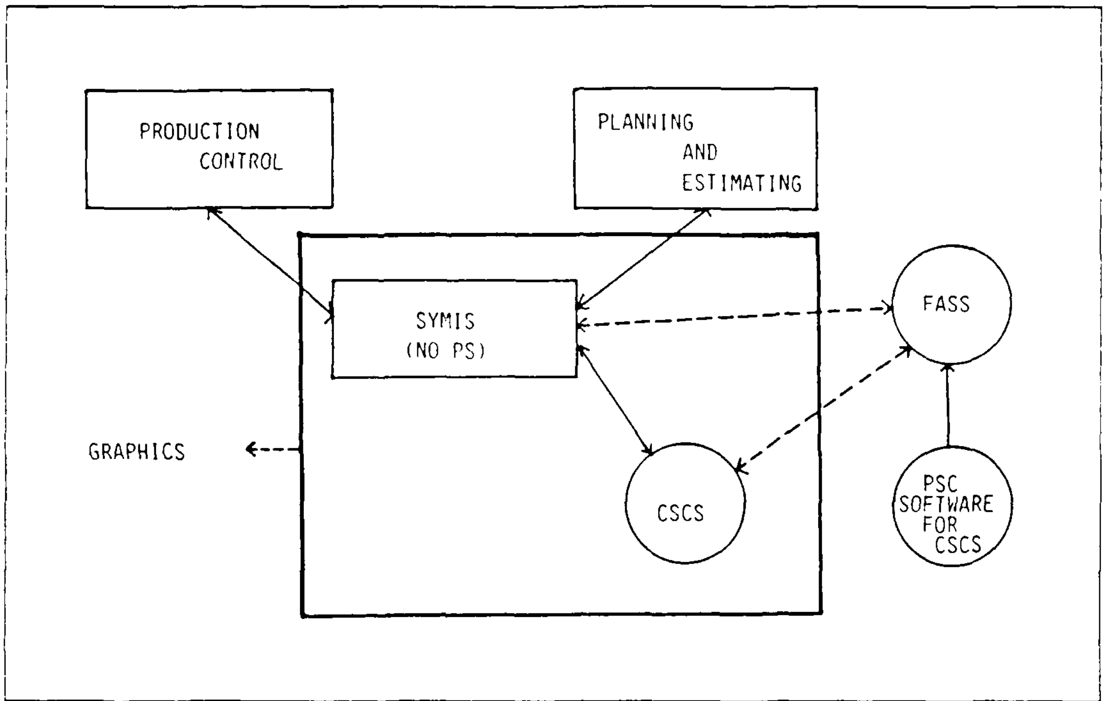

Figure 6.6 Charleston Production Planning Branch Network.

waterfront for added emphasis. Another accomplishment in their FASS displays is that after a plot has been completed the information excess is deleted thus conserving disk space. Also when the plot is updated the information is stored in the SYMIS rather than FASS. The reports that Portsmouth uses are the same as the other shipyards. Portsmouth does not have the float allocation application. They are organized with a Code 379 to take advantage of that section of production control's expertise in developing new and more useful reports to the keyop managers and other top management in the shipyard. Code 379 tracks all of FASS's data sets, global variables, and fields. They have not experienced any problems in interfacing via modem with the other shipyard FASS systems and only minimal communications difficulty interfacing with the shipyard mainframe. Portsmouth is the shipyard that has had FASS for the longest period and its experience is in demand at the User's Group conferences.

H. NORFOLK

Norfolk Naval Shipyard is the largest of the naval shipyards. The line diagram is shown in Figure 6.8. It has become imperative that scheduling and cost controls be

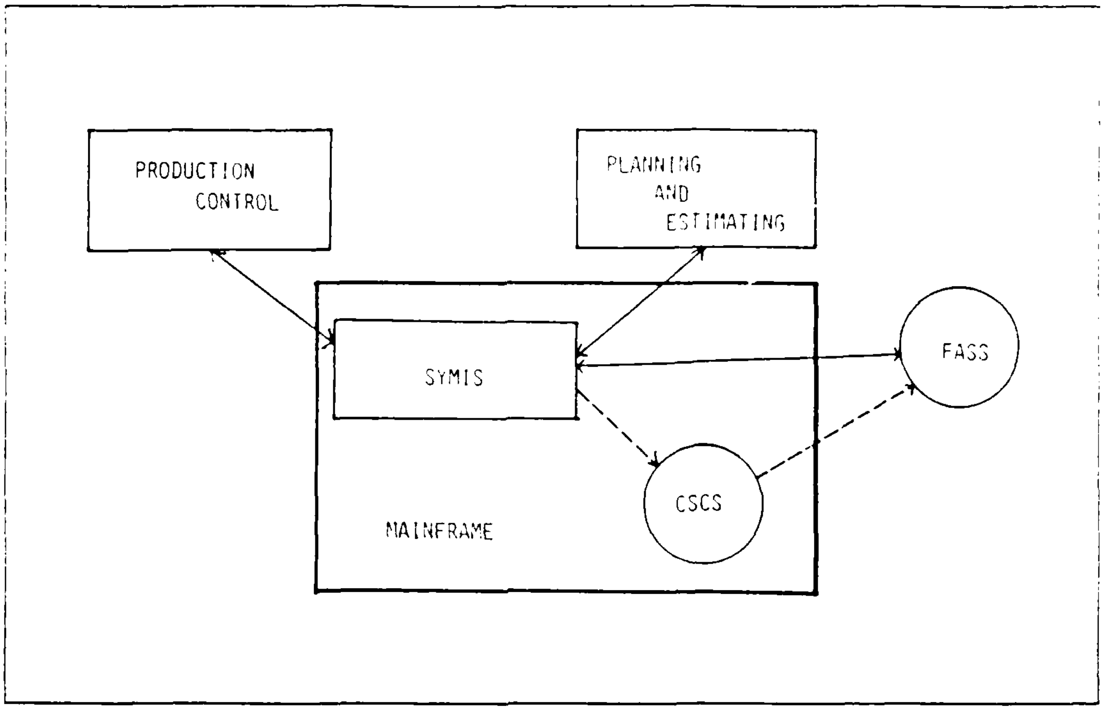

Figure 6.7 Portsmouth Production Planning Branch Network.

taken in hand as quickly as possible. Norfolk has fully implemented FASS and CSCS with good results. The FASS is menu driven with command files for producing graphics and reports. It also issues bar charts and PERT networks to the waterfront and has a strong teaching cadre for CSCS. All ships currently in overhaul at Norfolk are on ARTEMIS. Norfolk probably makes the most use of its overhaul library disk based on the pure volume of ships in overhaul. Norfolk has an excellent communication system between the shipyard and the waterfront and has a large number of remote sites for a more real time look at all jobs being accomplished by the shipyard. Because of its size Norfolk is experiencing some problems in their networks and with the communication protocols with the mainframe. They use the 2780 protocol exclusively at this point. Norfolk is currently unable to run multiple plotters at 9600 baud where the other shipyards have not indicated any problem in that area. The organization at Norfolk is the standard organization cited in Chapter V, with FASS under Code 377. One political problem that is surfacing is between FASS and the ADP personnel that run the mainframe. The people that run the mainframe feel that FASS should be able to run itself and discourage use of the mainframe for the heavy memory work. FASS also wants to access the PC file but are not allowed by the shipyard ADP personnel. Norfolk is trying to resolve these problems expeditiously because FASS cannot run as a stand alone system and deliver the reports that the keyop managers must have to make their decisions. These reports are issued once a week and are a tremendous asset for the keyop managers in finding problems early.

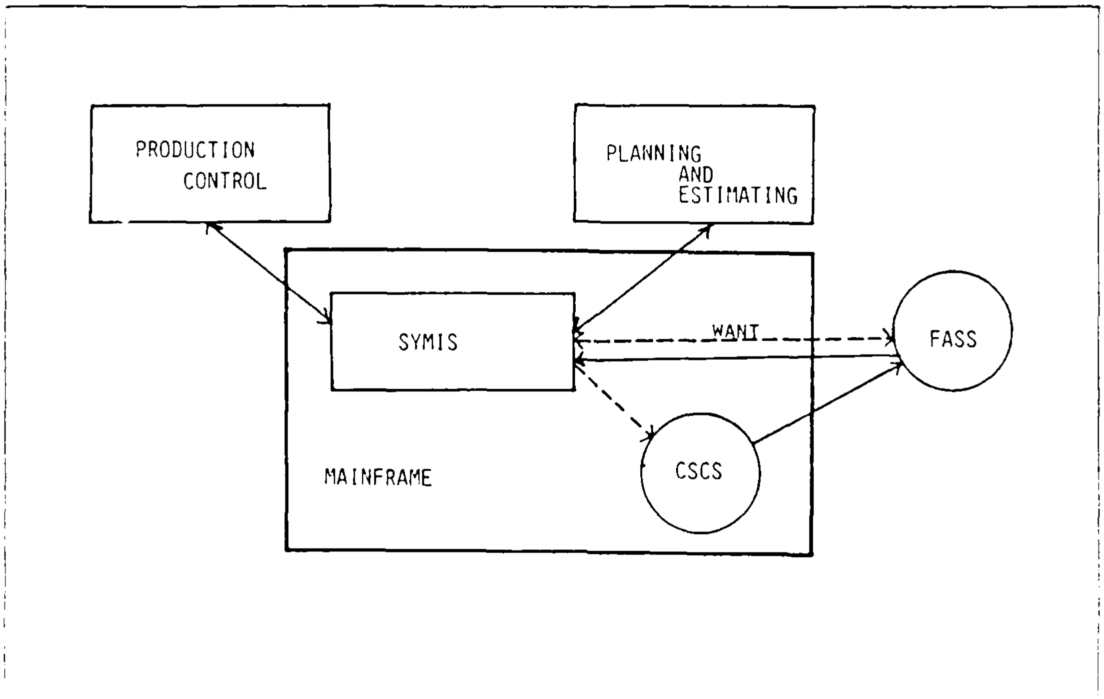

Figure 6.8 Norfolk Production Planning Branch Network.

VII. CONCLUSIONS / RECOMMENDATIONS

A. CONCLUSIONS

1. FASS USEFULNESS

After completion of the interviews and documentation reviews associated with system specifications, requirement analysis, official correspondence, personnel requirements, background and plans concerned with the acquisition, implementation and utilization of FASS, it is evident that:

* Personnel involved at all levels are dedicated to obtaining a uniformly high quality product useable by all shipyards.
* Personnel requirements are interpreted very differently at all shipyards and even at different levels in each shipyard, ranging from impressive to minimal.
* Definition of what FASS is, and what it should be used for, varies greatly in its extent yet does not vary in what it is.
* FASS is meeting all requirements and specifications as determined prior to purchase; however use of the system has shown that all requirements and specifications were not defined enough to meet todays requirements.
* The selected ARTEMIS system is having a positive impact on the the shipyard scheduling process and overall effectiveness.

When used as designed, or as modified to meet the individual shipyards requirements FASS will continue to have a growing impact on all shipyards both operationally and economically. With continued and improved communications between all shipyards, NAVSEA, and SEAADSA, FASS will continue to be modified to support the present and ever changing demands placed on it by the users.

2. NETWORKING

A key concern of each shipyard continues to be just how to, and to what extent, FASS should be networked with the existing systems. FASS was designed as a stand alone system but has proven to be more fully utilized if networked with the existing shipyard systems. The limited memory capacity of FASS requires it to use the data storage capacity which resides in the existing shipyard computer systems to obtain maximum efficiency. This requirement must be met by the required data stored in the SYMIS being passed to FASS via a network scheme of some type thus allowing FASS to use its limited memory capacity for processing vice the data storage. This requirement could be met by manual entry of data as it is required; however, this would be a step back in time negating one of the major qualities of FASS that being the timeliness of FASS provided information and results.

3. **ACCEPTANCE**

Shipyard management has met the test and although each has answered it in slightly different ways all have passed by proving that FASS is now and will be the only way to do scheduling in the shipyards. Some of the upper management have used the "JUST DO IT" approach while others have been more diplomatic in their approach but the end result has been the same as all levels of all eight shipyards are rapidly joining or are already on board that FASS is the only way to go now and in the future. With each modification to FASS, management will again have to face the acceptance problems but they will be much smaller in magnitude and should be much easier to meet.

4. **GROWTH POTENTIAL**

As FASS is accepted to greater levels in the shipyards it will face an ever increasing problem with growth. That is; as the managers, supervisors, and users more fully comprehend and understand the systems applications, they will want to have the system do more and more things for them in their own way. Many different reports and graphs can be generated by both the main and desktop versions making it very attractive for each person to want to have the data entered or presented in a special way for his specific need. This type of usage not only duplicates information storage requirements but also increases processing time taking it away from other services the system was initially designed for. Growth of this type is not necessarily wrong but is a major control problem as more personnel become familiar with the system.

5. **CONTROL**

As reflected in the previous section on Growth, a frequent problem associated with computer systems is the growth of its usage after the initial learning phase is completed. This problem requires close and continued attention by upper level shipyard management and is a primary reason for the formation of Code 379 as a central control point for the overseeing and regulation of the usage of FASS. Continued success of the system depends on employing it for additional applications; however, these applications must be uniform and applicable to more than just one user of the system. A prime example of this is the introduction of CSCS onto the system only to find that while it has produced good results it has overloaded FASS and decreased its usefulness for its intended purpose: Scheduling. This does not suggest that new and useful modifications cannot be made to FASS but that the introduction of such modifications must be carefully controlled and monitored. This control is being done by local FASS managers and overall by SEAADSA and the FASS users group.

6. PERSONNEL MANNING AND UTILIZATION

The status of personnel manning at all eight shipyards in the area of FASS is up in the air without a standard policy for having or not having a Code 379. Each individual shipyard has gone its own way in establishing just what its manning will be and what it will be called. In order for FASS to be utilized as it was designed to do a standard policy must be set and adhered to as much as possible considering the differences in the networking methods applied by each shipyard.

The authorized and actual manning levels are summarized below in Table 1.

TABLE 1

FASS MANNING LEVELS

SHIPYARD	AUTHORIZED	ACTUAL	CODE
Puget Sound	9	5	379
Long Beach	5	3	379
Mare Island	2	2	379
Pearl Harbor	1	1	375.1
Philadelphia	7	2	226
Charleston	6	4	377
Portsmouth	7	7	379
Norfolk	1	1	377.6

The request produced by Portsmouth Naval Shipyard is a start in the right direction. Without a common code with a common experience level required for that code it will continue to be a problem for the shipyards to communicate and work with each other. Despite the best intentions of all involved a GS-9 with only a scheduling background working in code 377.9 cannot accomplish as much as a GS-12 with both scheduling and computer background working in code 379 when dealing with other code 379s from other shipyards or when dealing with the contractors involved.

7. COST/SCHEDULE CONTROL SYSTEM

While CSCS is a very important and valuable requirement for operation of the shipyard its association with FASS is not desirable. After close review of the Long Beach, Mare Island, and Charleston initiatives several items concerning the development of a standard CSCS automation are evident:

* Use of estimates versus allowances or the combination of the two in performing CSCS calculations.

* Where data originates and how it becomes part of the Production Control master file in each shipyard.
* Calculation of the Budgeted Cost of Work Scheduled (BCWS). Three curves are being used or planned (Original BCWS, Current BCWS, and Revised BCWS).
* Which schedule dates are being used (early start early finish or allocated start allocated finish) to trace work and what is the potential effect on schedule variance?
* Schedule variance at the line item level when estimates are made at the key operation level.
* Should CSCS calculations take place on the mainframe, minicomputer (FASS), or combination of the two?
* Where should CSCS graphics be produced, how should they be distributed, and how many copies of each?

The Cost/Schedule Control System is still in the developmental stages of its use in Naval shipyards and as such many of the answers are not yet available. A continuing process of solicitation of requirements and the follow up feedback is necessary.

8. IN-HOUSE REVIEW

FASS has now been in use at Portsmouth and Mare Island for an extended period of time allowing these shipyards to conduct an in-house review of the systems effectiveness and use-ability. The other shipyards may at any time conduct their own in house review but must take into account the time period the system has been in place and the amount of exposure to the total shipyard workforce it has had. This review is not meant to be a one time event and must be an ongoing requirement placed on the FASS system managers by the shipyard commanders if FASS is to continue to be utilized and improve as it has demonstrated it has the capability of doing. The areas covered by the review may vary from shipyard to shipyard and time to time but the major areas that should be covered are:

* Assessment of overall performance of the system. Is it an asset or has it become a liability?
* Accessibility and response time.
* Information flow, amount, and form.
* Program effectiveness.
* Training effectiveness.
* Are there confusing or unused areas of the system?
* Is FASS assisting or burdening the supervisors?
* Is the system being utilized by all levels and areas of the shipyard?

These on going reviews will take a considerable amount of time but are necessary to preclude the possibility of misuse or nonuse of the system. [Ref. 13]

9. NAVSEA REVIEW

In that each shipyard has undertaken an individual approach to FASS and its utilization the effectiveness of each approach must be evaluated by an outside source (in this case NAVSEA). Just because one shipyard is having great success with one form of implementation and utilization of FASS is definitly no guarantee that the other seven shipyards would succeed using that form. The major factor affecting the success or failure of the system at individual shipyards may not be in the method of implementation and utilization but instead might be management support, training or acceptance. [Ref. 14] These factors cannot be reviewed by internal organizations and must be approached from a knowledgeable but disinterested point of view.

B. RECOMMENDATIONS

1. SHIPYARDS

The following list of recommendations apply to all of the shipyards or interactions between them:

* Establish a common basis for utilizing FASS for its intended purpose: Scheduling.
* Establish a common dataset definition for mandatory fields to be extracted from the SYMIS master files for FASS use.
* Report results and findings of resource leveling efforts on FASS for use by all shipyards.
* Promulgate command file and documentation for loading shop work center information as network resource records.
* Review float allocation for use and optimization by all shipyards.
* Promulgate the source and extent of CALCOMP expertise for the benefit of all shipyards.
* Review TLR updating process for replacement by FASS applications, in the two shipyards that are still using PS(TLR).
* Promulgate process for updating network based on actual finish dates and physical progress.
* Share the Puget Sound Naval Shipyard Event Management and Lead Shop Key Shop instruction.
* Provide a network for checking validation files (dummies, loop) prior to input to SYMIS or other systems.
* Develop lists of scheduling problems, scheduling methodology used, types of schedules, and types of reports used for exchange with each other and discussion at following FASS users group meetings.
* Develop lists of hardware software or system utilization problems for discussion resolution at following FASS users group meetings.

* Exchange samples of FASS products as produced at individual shipyards.
* Utilize SEAADSA as a central design agency for new standard applications.

2. **SEAADSA**

SEAADSA should be responsible for acquiring providing the following items:

* Development of new standard applications as required by the shipyards.
* Timing test results on Metier float allocation process using large sized network data to evaluate the extent of the slow-down problem.
* Establish communication with the ARTEMIS users association to exchange routines of possible interest to Navy or other FASS users.

3. **NAVSEA**

It is recommended that NAVSEA do the following:

* Take action expeditiously on the Portsmouth Naval Shipyard request for establishment of Code 379. Consider the extensive merits of establishing a Code 379 at all shipyards as part of the standard shipyard organization.
* Promulgate, in writing, the NAVSEA policy for FASS information and data sharing in light of the requirement for competitive bidding between shipyards.
* Establish a policy for integration of FASS within each shipyard information processing system.
* Establish policy for CSCS calculations to be achieved on the SYMIS. Graphic products should also be generated on the mainframe due to volume and distribution considerations.
* Direct the formation of an advisory group to the CSCS Implementation Review Team consisting of shipyard personnel who are being tasked to implement the automation of the CSCS tool in the shipyards.

VIII. FURTHER RESEARCH OPTIONS

By January 1987 the entire shipyard complex should be capable of using ARTEMIS version 6.1 as their main scheduling tool as well as for Cost Schedule Control. The different implementation approaches along with the varied results in networking and utilization of FASS will provide an excellent opportunity for further research on (1) How the shipyards view FASS, (2) How the shipyards utilize FASS, and (3) Lessons learned concerning the purchase and use of commercial software altered for use in the Naval shipyards. A study of these lessons will identify actions required for success which in turn will benefit all aspects of computer use in the government military complex.

LIST OF REFERENCES

1. Director, Management Systems Support Division UNCLASS Letter 5230: Ser 148/705 to all Naval Shipyard Commanders, Subject:*Status of Fundamental Automated Scheduling Systems(FASS) Procurement (U)*, 3 August 1984.

2. Secretary of the Navy, Notice 5450, 21 April 1956.

3. Commander, Puget Sound Naval Shipyard Instruction 5450.8E, *Shipyard Organization Manual*, 1 June 1972.

4. Management Systems Support Division, *System Decision Paper to the Interim Automated Scheduling System*, September 1983.

5. Commander Puget Sound Naval Shipyard Instruction 4850.19, *Event Management*, 29 November 1984.

6. Leachman, Robert C., Kim, Sooyoung, and Chou, Shrane Koung, *Guide to Simulation Scheduling*, Operations Research Center, University of California at Berkely, January 1986.

7. Naval Sea Systems Command Instruction 4850.9, *Non Nuclear Scheduling Instruction*, 28 February 1984.

8. Management Systems Support Division, *System Decision Paper to the Interim Automated Scheduling System*, September 1983.

9. Management Systems Support Division, *Fundamental Automated Scheduling System, System Specifications*, July 1984.

10. FASS User Group, *FASS User Group Charter*, March 1985.

11. Puget Sound Naval Shipyard Training Manual, *Cost/Schedule Control System*, undated.

12. Naval Sea Systems Command Instruction 7000.13, *Cost and Schedule Control in Naval Shipyards*, 3 December 1984.

13. McLoed, R., *Management Information Systems*, pp 620-623, Science Research Associates, Inc., undated

14. Bloomer, T.L., "Do You Always Run a Gauntlet Trying to Effect Change?" *Program Manager*, vol. XIII, pp 10-13 November-December 1984.

BIBLIOGRAPHY

Burch, J. G., Grudnikski, G., and Strater, F. R., *Information Systems: Theory and Practice*, 2nd ed., John Wiley and Sons, Inc., 1979.

Burton, K., "System Integration Vital to Role of MIS Executives," *Computer World*, vol. 18, pp 32-35, 26 November 1984.

Chacko, G. K., *Management Information Systems*, Petrocelli books, Inc., 1969.

Dane, C. W., Grey, C. F., and Woodworth, B. M., "Factors Affecting the Successful Application of PERT CPM Systems in a Government Organization," *Interfaces*, vol. 9, November 1979.

Goldkuhl, G., Nilason, A., and Lundberg, M., *Information Systems Development*, Prentice-Hall., Inc., 1981.

Linder, J. C., "Avoiding Information Systems Failures," *Informations Systems*, vol. 31, pp 98-100, October 1984.

Lucas, Henry C., *Information Systems Concepts for Management*, McGraw-Hill, 1978.

Pressman, Roger S., *Software Engineering: A Practitioner's Approach*, McGraw-Hill, 1982.

Project Systems Consultants, Inc., *Analysis and Recommendations for Management Information Systems at Mare Island Naval Shipyard*, 4 September 1984.

Project Systems Consultants, Inc., *Proposal to SEAADSA for Artemis Related Services and Products*, 22 November 1983.

Project Systems Consultants, Inc., *Naval Regional Contracting Center Solicitation NO. N00600-84-R-4027, Technical and Cost Proposal*, 27 September 1984.

Sheddon, J. G., "Concerting to a Package: Advice from the Trenches on how to Replace an Aging Production System with an off-the-shelf Product," *Datamation*, vol. 29, October 1983.

Skinner, Wickham, *Manufacturing in the Corporate Strategy*, John Wiley & Sons, 1978.

Synnott, William R. and Gruber, W. H., *Information Resource Management: Opportunities and Strategies for the 1980's*, John Wiley & Sons, 1981.

Yadow, Surya B., "Determining an Organization's Information Requirements: A state of the Art Survey," *Data Base*, pp. 3-20, Spring 1983.

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